DRAFT FEASIBILITY STUDY AND ALTERNATIVES EVALUATION

RHINE CHANNEL SEDIMENT REMEDIATION
NEWPORT BAY, CALIFORNIA

Submitted to

Orange County Coastkeeper,

California Regional Water Quality Control Board,

and

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Table of Contents

List of Tables

List of Figures

List of Appendices

1 INTRODUCTION

The Rhine Channel Sediment Remediation Feasibility Study presents the results of a sediment investigation conducted in 2004 to delineate the vertical and horizontal extents of sediment contamination within the channel. This, and previous site data, were subsequently used to conduct a detailed feasibility study of remediation alternatives with the goal of restoring beneficial uses to the channel. This document presents the results of the sediment investigation and detailed feasibility study for site remediation. Alternatives are presented and evaluated against a set of engineering and environmental criteria to determine project suitability and a preferred alternative is recommended.

1.1 Site Description

The Rhine Channel is a small, closed-ended navigation channel located in the western part of Newport Bay in Newport Beach, California (see the Vicinity Map, Figure 1). Over the past 80 years, the Rhine Channel has served as the primary industrial area in the Bay with current and past businesses including boatyards, metal plating facilities, and a seafood cannery. While some small boatyards and retail boat suppliers are still located along the Rhine Channel, the area is currently in transition from an industrial area to a residential and recreational area. Since the site's original creation in 1920, sediments within the channel have never been dredged and are known to contain elevated concentrations of metals, polycyclic aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyl (PCBs) from decades of industrial discharges and stormwater runoff.

The study area for the Rhine Channel Sediment Remediation Feasibility Study extends from the turning basin near the former cannery to the north, and to the entrance of the channel near 19^{th} Street to the south (Figures 2A and 2B). Historical sediment inputs to the channel are primarily limited to discharges from storm drains, of which there are estimated to be seven entering the study area (Figures 2A and 2B).

1.2 Project Background

A Total Maximum Daily Load (TMDL) identifies the maximum amount of a pollutant that may be discharged to a water body without causing exceedences of water quality standards and impairment of the uses of these waters. The federal Clean Water Act (CWA) requires development of TMDLs for polluted waters to assist in identifying pollutant control needs and opportunities. Section 303(d)(1)(A) of the CWA requires that "Each State shall identify those waters within its boundaries for which the effluent limitations...are not stringent enough to implement any water quality standard applicable to such waters." The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and establish TMDLs for such waters.

As part of California's 1996 and 1998 Section 303(d) lists, the California State Regional Water Quality Control Board (RWQCB; Santa Ana Region) identified Newport Bay and San Diego Creek as water quality limited due to several toxic pollutants and designated this watershed as a high priority for TMDL development.

The Environmental Protection Agency (EPA) has oversight authority for the 303(d) program and is required to review and either approve or reject the TMDLs submitted by states. If the EPA rejects a TMDL submitted by a state, the EPA is required to establish a TMDL for that water body.

On October 31, 1997, EPA entered into a consent decree (decree), Defend the Bay, Inc. v. Marcus, (N.D. Cal. No. C 97-3997 MMC), which established a schedule for development of TMDLs in San Diego Creek and Newport Bay. The decree required development of TMDLs for several toxic pollutants by January 15, 2002. The agreement also provided that EPA would establish the required TMDLs within 90 days, if the State failed to establish an approved TMDL by the deadline.

In early April 2002, the decree was modified to extend the deadline for EPA's establishment of these TMDLs to June 15, 2002. On June 14, 2002, the EPA released the document titled *Total Maximum Daily Loads For Toxic Pollutants San Diego Creek and Newport Bay, California* containing TMDLs for several chemicals in the Bay. TMDLs specific for the Rhine Channel and Lower Newport Bay include the following: copper, lead, selenium, zinc, chromium, mercury, chlordane, dieldrin, DDT, and PCBs.

To comply with the TMDLs developed for the Bay, and restore beneficial uses to the Rhine Channel, target sediment cleanup values were developed for the channel and are presented in Table 1. These target values were used in the current study to determine areas requiring attention. A more detailed discussion is provided in Section 2.1.

1.3 Project Objectives and Tasks

The overall objective for this study is to restore beneficial uses to the Rhine Channel and Lower Newport Bay by eliminating existing risks associated with elevated chemicals in the water and sediments. The beneficial uses of Lower Newport Bay include: Navigation (NAV), Water Contact Recreation (REC1), Non-contact Water Recreation (REC2), Commercial and Sportfishing (COMM), Wildlife Habitat (WILD), Rare, Threatened or Endangered Species (RARE), Spawning, Reproduction, and Development (SPWN), Marine Habitat (MAR), and Shellfish Harvesting (SHEL). The benefits of site remediation include improved ecosystem conditions, more abundant wildlife, lower concentrations of pollutants in water and sediment, lower concentrations of pollutants in fish and shellfish tissue, and a non-degraded benthic community.

Because the Rhine Channel sediments are known to contain elevated concentrations of metals, pesticides, PAHs, and PCBs, it is expected that restoring these beneficial uses to the channel will require some form of removal or encapsulation of the sediments to eliminate the exposure pathway to aquatic organisms residing in the channel and elsewhere in Newport Bay.

Meeting this study objective required the development and implementation of several smaller tasks, including:

- Reviewing existing biological and chemical data for the Rhine Channel and developing a sampling plan for collecting additional data
- Collecting additional site data on:
    - vertical and spatial extent of chemical concentrations
    - geotechnical characteristics of the sediment
    - debris field mapping of the channel
    - structural quality of existing shoreline structures
    - ecological risks associated with existing sediment chemical concentrations
- Formulating alternatives for meeting the overall program objective
- Screening the alternatives for feasibility with the local stakeholders

- Conducting a detailed evaluation of each alternative, including engineering feasibility, permitability, environmental protection, and costs

2 SITE CLEANUP REQUIREMENTS

As stated in Section 1, the goal of this study was to evaluate options for restoring aquatic life and other beneficial uses to the Rhine Channel. In its document *Total Maximum Daily Load for Toxic Pollutants San Diego Creek and Newport Bay, California,* the EPA has determined that complying with the metals and organics TMDLs developed for the Bay will allow these beneficial uses to be restored. The site cleanup criteria used in this evaluation have been based on that assumption.

2.1 Cleanup Standards

The cleanup standards used in this alternatives evaluation are primarily based on the TMDLs developed by EPA for Newport Bay (EPA 2002). Table 1 presents a summary of the TMDLs developed for Lower Newport Bay and the Rhine Channel. Because TMDLs do not exist for many of the chemicals of concern (COCs) at this site, additional cleanup values were needed. Effects range-low (ER-L) and effects range-median (ER-M) values were added for all COCs where a TMDL was not available. Table 2 presents a summary of the complete list of screening criteria used to determine areas considered for remediation.

2.2 Applicable Federal, State, and Local Laws

Federal, state and local laws governing activities related to the Rhine Channel sediment remediation project include the following:

- Santa Ana RWQCB/EPA toxic TMDLs and Basin Plan objectives for San Diego Creek and Newport Bay
- U.S. Army Corps of Engineers and EPA Inland Testing Manual and Ocean Disposal Guidelines
- State of California Bays and Estuary Plan (SWRCB 2000)
- California Code of Regulations Title 27, Division 2, Subdivision 1 of the Solid Waste Regulations
- U.S. Fish and Wildlife Service and NMFS consultation on the Federal Endangered Species Act
- California Department of Fish and Game consultation on the California Endangered Species Act
- NMFS consultation on the Marine Mammal Protection Act of 1972
- EPA Clean Water Act, Section 401

- U.S. Army Corps of Engineers, Clean Water Act, Section 404; Rivers and Harbors Act, Section 10

3 SEDIMENT CHARACTERIZATION

3.1 Previous Sediment Investigations

Previous sediment studies have been conducted in the Rhine Channel by Phillips et al. (1998), the City of Newport Beach, Orange County Coastkeeper (1999) and the Southern California Coastal Water Research Project (SCCWRP) (Bay and Brown 2003). These studies identified numerous contaminants of concern including heavy metals chromium, copper, mercury, lead, selenium, and zinc; PCBs; and pesticides that are above ER-L and ER-M values (Long et al 1995) and are suspected of causing toxicity to benthic organisms. In 1999, the State Water Resource Control Board (SWRCB), through the Bay Protection and Toxic Cleanup Program (BPTCP), listed the Rhine Channel as a toxic hot spot. Remedial action at the site is considered a high priority by the SWRCB.

In 2002, a focused sediment investigation was conducted along the shoreline of the former South Coast Shipyard by Petra Geotechnical, Inc. to support a transfer agreement between the former property owner (Mr. William Blurock) and the current land developer for a potential renovation project (ETCO Investments). Proposed activities include updating the bulkhead, replacing the docks, removing a small quantity of sediment that has shoaled in front of the docks, and filling in one of the former ship ways. To investigate potential contaminants in the dredge material, surface and subsurface sediment samples were collected from stations along the current bulkhead. The results of that investigation showed sporadic metals concentrations with some lead and copper levels above hazardous waste levels.

In summary, the previous studies have identified the spatial extent of surface sediment contamination and a limited assessment of vertical contamination. However, a detailed and thorough analysis of the vertical extent of the sediment contamination was needed before developing alternatives for remediation of the Rhine Channel. The current study was proposed and implemented to fill this data gap.

3.2 Current Sampling and Analysis Program

The current project was designed to determine the vertical and spatial extent of sediment contamination within and below the chemically impacted surface sediments and identify the depth at which uncontaminated sediments were reached. The project characterized the nature and extent of the site contamination so that remediation alternatives could be identified, and evaluated which alternatives comply with the SWRCB's toxic hot spot cleanup plan (1999) and the toxic TMDLs set forth by the EPA (2002).

All field and laboratory work was performed in accordance with the methods and procedures described in the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) prepared by Orange County Coastkeeper (OCCK 2004a and 2004b, respectively).

In November 2004, core samples were collected by Anchor Environmental and Orange County Coastkeeper staff at 16 stations (Figures 2A and 2B) that coincided with SCCWRPs previous surface sediment investigation. The original station locations were chosen to represent, as accurately as possible, the spatial variability of physical and chemical characteristics found throughout the Rhine Channel. One of the stations (Station 16 located near the 25th Street storm drain) was not sampled during the SCCWRP investigation, but was added to help delineate potential contamination in that area.

The core sample collection and sub-sampling techniques followed the EPA-approved procedures outlined in the project SAP and QAPP (OCCK 2004a and 2004b). Core samples were driven into the sediments until the depth of refusal was reached using a hand operated piston corer. The cores were then capped and immediately transferred from the sampling boat to a team on the shore where they were split and processed. A California-registered geologist inspected the cores for distinct geologic layers, color, texture, and odor and recorded the observations on field datasheets. Electronic replications of the field datasheets can be found in Appendix A. Visual inspection also verified that the cores penetrated the native, underlying material. The sampling procedure was repeated if the core did not appear to reach the sandy native material[1].

Composite samples were taken from the surface sediments above the interface of the overlying sediments/native layer and from within the native layer, and placed in pre-

[1] Because the original design drawings for the Rhine Channel were not available, it was necessary to assume that the interface between the fine-grained silty material present in the upper layers and the course sand layer which was found below the silty layer represented the original design depth for the Channel.

cleaned jars supplied by the laboratory. Additional samples were taken from the core if distinct geologic layers were visually identified. All samples were analyzed for metals, PCBs, DDT and its metabolites, PAHs, and total organic carbon (TOC) (Table 3). Sample jars were immediately placed on ice after sampling and shipped to CRG Marine Sciences Laboratory (CRG Labs) in Costa Mesa, California. Additionally, grain size, moisture content, porosity, specific gravity, and Atterberg limits were determined for three additional cores that were sent to the laboratory intact.

Samples for trace metal analysis were prepared using EPA Method 3015 and analyzed by Inductively Coupled Plasma Mass Spectrometry (ICPMS) using EPA Method 6020. Samples for organics analysis were extracted using EPA Method 3540 and analyzed by Gas Chromatography/Mass Spectrometry (GC/MS) by EPA Method 8270. Chemical analyses were conducted by CRG Labs in Torrance, California. TOC concentrations were determined by EPA Method 415.1 performed by Aquatic Bioassay and Consulting Laboratories in Ventura, California.

Laboratory results from the November sampling event indicated the clean native layer had not been reached at two locations. Sediment cores were therefore re-collected at Stations RS04-14 and 16 in February 2005. Composite samples were taken from the surface, middle, and bottom layers of each of additional core and analyzed only for metals (Table 3) as they represented indicator chemicals for determining the depth to the clean native layer for each location.

The November 2004 results also indicated elevated levels of mercury in the sediments at various stations. Additional samples were therefore taken at four stations within the channel to measure total and methyl mercury concentrations as a method of assessing potential ecological risk. Total and methyl mercury sampling was conducted using EPA's "clean" sampling techniques to ensure that cross-contamination of the samples did not occur.

Two total and methyl mercury samples were collected from each of the sediment cores re-collected from Stations RS04-14 and 16 (top 2 centimeters [cm] and 20–22 cm). Two additional surface (0–2 cm) samples were also collected for total and methyl mercury analysis from Stations RS04-01 and 04 using a petite ponar grab to provide more spatial coverage for the analyses. Two sample depths were analyzed for some of the stations as a way to determine variations in mercury methylation rates by depth. All mercury samples were placed in 50 gram vials, doubled bagged in plastic bags supplied by the lab, and then immediately placed on dry ice. The samples were sent priority overnight to Studio Geochemica in Seattle, Washington for analysis. (See Appendix B for the analysis procedure.)

Sample results from both the November 2004 and February 2005 sampling events are discussed in the following section. Results from the mercury study is discussed in Section 3.4

3.3 Analytical Results

A total of 49 sediment samples were analyzed for chemical constituents from the 16 sampling stations (station locations shown on Figures 2A and 2B). Table 3 presents the sediment chemistry results for metals, PAHs and PCBs measured in each sample interval. Chemical concentrations measured in the sediments have been compared to ER-L and ER-M thresholds (Long et al. 1995), and TMDL levels where applicable. These values and the Bay and Brown 2003 surface sediment data are provided in Table 3 for comparison purposes.

Metals were detected in the surface sediments at all stations which agreed with SCCWRPs findings (Bay and Brown 2003). Arsenic, cadmium, copper, lead, mercury, nickel, and zinc were all detected at concentrations above ER-Ls at stations throughout the channel in both the surface and subsurface sediments (Table 3). Particularly high concentrations were noted in the samples for copper, mercury, and zinc, which were all measured above the ER-M values of 270 mg/kg, 0.71 mg/kg, and 410 mg/kg respectively. TMDL levels of 0.67 mg/kg, 18.7 mg/kg, 30.2 mg/kg, 124 mg/kg, and 3.89 μg/kg have been set for cadmium, copper, lead, zinc and total DDT, respectively for the Rhine Channel by the EPA. All of these concentrations were consistently exceeded throughout the channel sediments.

Mercury concentrations were also consistently measured above the ER-L in sediments thought to be located within the underlying native layer. This was most evident at stations RS04-14 and 16 which also had numerous other metal concentrations that were above their respective ER-Ls (Table 3). It was unclear if the native layer was not reached at these two locations or if there was cross contamination of the samples during the sampling process. Therefore, core samples were re-collected at Stations RS04-14 and 16 in February 2005 along with surface grab samples at Stations RS04-01 and 04 (mercury only) as previously described.

As with the previous results, the additional cores revealed that concentrations of arsenic, copper, lead, and zinc all exceeded the TMDL and ER-L levels in surface sediments at both Stations RS04-14 and 16 (Table 3). Also in the surface sediments, mercury concentrations exceeded the ER-M level at both stations and cadmium exceeded the TMDL level at Station RS04-16. However, this time no metals concentrations were detected above ER-L and ER-M threshold values or TMDL values in the subsurface or bottom sediments. As a result, it was determined that the depth to the "clean" native layer was successfully achieved at both locations during this second round of testing.

In 2002, SCCWRP consistently detected total DDT concentrations above the ER-M threshold of 46.1 μg/kg in surface sediments throughout the Rhine Channel. The current study measured concentrations of 4,4' DDE, a metabolite of DDT, in the surface sediments at Stations RS04-02, 04, 09, and 15 above the total DDT ER-L threshold of 1.58 μg/kg and TMDL level of 3.89 μg/kg. It was also detected in the subsurface sediments (60 – 120 cm) at Station RS04-01 above the total DDT ER-M threshold.

Elevated total PAH concentrations were detected in surface sediments at all stations in 2002 by SCCWRP (2003). Stations RS04-01, 07, 10, and 15 had concentrations above the ER-L threshold of 22.7 μg/kg; the rest of the stations were above the above the ER-M threshold of 180 μg/kg (Table 3). PAHs were again detected during the November 2004 study at all stations except RS04-05, 08, 13, 14, and 15, but generally only above the ER-L threshold value.

Total and methyl mercury concentrations for each sample are summarized in Table 4 and presented graphically in Figure 4. The following section provides a detailed discussion of the mercury methylation results.

3.4 Data Evaluation

In addition to simple comparisons of the sediment chemical concentrations to the screening values presented in Table 1, several methods for evaluating potential impacts associated with the elevated sediments in the Rhine Channel were also employed. These included evaluating mercury methylation rates in the sediment, normalizing the metals data to ambient iron concentrations, considering quotient based screening values, and evaluating bioaccumulation risks to benthic organisms, fish, and aquatic birds. The results of these additional data evaluations are presented in the following sections.

3.4.1 Methyl Mercury Production

Mercury in the environment is primary found in its inorganic state, but can be transformed into a more toxic organic form, called methyl mercury, by natural processes within aquatic environments termed methylation. This transformation is mediated by sulfate-reducing bacteria, which are ubiquitous inhabitants of sediments. Upon production and release into porewaters or surface water itself, Methyl mercury exhibits a strong affinity for the surface of decaying plant material or it can become incorporated into the cells of living algae. Methyl mercury becomes concentrated in higher organisms by the process of biomagnification or bioaccumulation, a process by which contaminants are concentrated toward the apex of food webs.

Typically, methyl mercury only represents a small percentage of the total mercury in surface waters and sediments. Methyl mercury ratios in most systems range between 1-5 percent, with 10 percent considered a high level (USEPA 1997). Concentrations measured in the Rhine Channel sediments are much lower than this ranging between 0.01 – 0.043 percent. It should be noted, however, that these samples were collected in the winter, when methylation rates are typically at their lowest point. Re-sampling in the spring, when methylation rates are known to peak (Bloom et al. 1999), could produce higher values.

3.4.2 ER-M Quotient Evaluation

In recognition of compounded and synergistic effects from the occurrence of multiple contaminants in sediments, Long et al. (1998) presented the concept of an ER-M quotient for interpretation of sediment toxicity test results. For any suite of sediment chemicals with potential contaminant effects, individual concentrations are divided by the ER-M value, producing a corresponding ER-M quotient. These quotients are then totaled and divided by the number of compounds analyzed to give a mean ER-M quotient. Relative to controls, Long et al. (1998) found that 71 percent of amphipod bioassay tests indicated highly toxic response when mean ER-M quotients exceeded 1.0, and a 32 percent incidence within the mean ER-M quotient range of 0.11 to 1.0, also noting that the probability of significant toxicity generally increased with increasing numbers of chemicals that exceeded their ER-Ms.

Mean ERM quotients were calculated as follows:

Mean ERM quotient = (ArsenicQ + CadmiumQ + ChromiumQ + CopperZ + Lead Q + MercuryQ + NickelQ + Silver Q + ZincQ + Total DDTQ + Total PAHQ + Total PCBQ)/12

Table 5 presents the mean ER-M quotients for Stations RS04-01 through 16. Values that exceed 1.0 may indicate toxic sediment to benthic organisms. Surface sediments sampled at Stations RS04-14 and 16 all had mean ER-M quotients above 1.0. Stations RS04-01 and 02 also had mean ER-M quotients above 1.0 in subsurface sediments. This evaluation suggests that metals exceedances may be slightly overestimated when evaluating the data solely compared to individual screening values, as there were far fewer exceedances when using the quotient approach.

3.4.3 Iron Normalization Evaluation

Although industrialization and development in the coastal zone can result in elevated concentrations of heavy metals, nearly all metals occur naturally in estuarine sediments. Therefore, determination of the anthropogenic contribution of a given metal requires establishing the natural metal concentration for a particular sediment. Natural inputs, as well as inputs from contaminant sources, can be discerned by normalizing metal concentrations to aluminum, iron, or another determinant that is not distorted by anthropogenic inputs (Bruland et al. 1974; Trefry and Presley 1976; Trefry et al. 1985).

Metals concentrations were regressed with iron to identify sites where metal content may be influenced by anthropogenic inputs. Iron is a major constituent of sediment minerals and is usually well correlated with trace metals. Under natural conditions, when levels of iron are higher in a sediment sample, concentrations of trace metals are also generally higher. Plots of trace metals versus iron from an area with little or no pollutant inputs often show a strong linear relationship. Positive deviations from this linear trend help identify anthropogenic inputs of that trace metal to the sediment. This analysis was performed for all metals with an ER-M exceedance.

Concentrations of copper, mercury, and zinc exceeded their corresponding ER-M values at several stations. The positive deviations from the natural metal/iron relationship (solid line) are shown in Figure 5 indicating possible anthropogenic metal input at the specified stations. These results suggest that metals concentrations in Rhine Channel sediments cannot be attributed to naturally occurring concentrations, but rather occur from significant external inputs.

3.4.4 Bioaccumulation Risk Assessment Summary

A focused ecological risk assessment (EcoRA) was conducted to provide an estimate of baseline risk from bioaccumulation of contaminants of concern in the Rhine Channel to higher trophic levels of fishes, birds, and marine mammals. This assessment was designed to provide a baseline evaluation of existing risks to support the inclusion of a no-action alternative in the Feasibility Study. Technically, this assessment addressed the potential for food chain transfer of sediment-associated contaminants, including selected metals, PCBs and the pesticide DDE (a breakdown product of DDT), to higher trophic levels of fishes, birds, and marine mammals.

The process used in the EcoRA followed USEPA (1998) guidelines for ecological risk assessment and include a problem formulation, exposure and effects assessment, and risk analysis and uncertainty evaluation. The Gobas steady-state uptake model was used to evaluate bioaccumulation of non polar organic compounds (PCBs and DDE) and a bioconcentration factor (BCF) approach was applied to evaluate bioaccumulation of the inorganic metals, copper, mercury, and selenium. Both the Gobas model and BCF model are included as parts of the Corps Trophic Trace (Version 3.04; November 2003) software developed by the Waterways Experiment Station (WES) for use in evaluating contaminated sediment (www.wes.army.mil/el/trophictrace).

3.4.4.1 Problem Formulation

The problem formulation of an EcoRA establishes the ecotoxicological connections between receptors of concern (ROCs) and chemical of potential concern (COPCs) within a site conceptual model and describes the environmental setting, ecological resources and receptors of concern, chemicals of concern, the conceptual site model, and assessment endpoints and measures of exposure and effects. The conceptual site model was based primarily on trophic transfer of the COPCs through the food chain from sediment and water → invertebrates → forage species → piscivorous species, as generally framed by the Trophic Trace model.

Two dietary pathways were evaluated, a sediment-based pathway and a water-based pathway. At the beginning of this food chain were the following invertebrates:

- A benthic crustacean and a benthic polychaete to represent the sediment diet pathway
- A pelagic crustacean to represent the water diet pathway

At the second level of the food chain are organisms that prey on the invertebrates described above. In this model, two fish and one bird preyed on the invertebrates:

- Planktivorous fish (California killifish) feeding throughout the water column, primarily on pelagic invertebrates
- Benthivorous fish (diamond turbot and arrow goby) feeding on benthic polychaetes and crustaceans

At the third level of the food chain described in this model are organisms that prey on the planktivorous and benthivorous fish. This included two piscivorous bird species feeding exclusively on fishes (brown pelican and cormorant) and one piscivorous fish species (California halibut). In addition, the model included a marine mammal (harbor seal) feeding on the two larger flatfish species (turbot and halibut). The ROCs are summarized in Table 6.

For all ROCs, the assessment endpoints were survival, growth, and reproduction. Two approaches to evaluating risk were evaluated for the ROCs: media-based exposure comparisons, dietary exposure comparisons, and tissue-residue comparisons. For the fishes exposed to mercury, PCBs, and DDE, the measure of exposure and effect was a comparison of modeled tissue data to residue-effects data. For the fishes exposed to copper and selenium, which are essential nutrients that are compartmentalized in different organs, the measure of exposure and effect was a comparison of modeled tissue data to dietary toxicity reference values. For the birds and mammals, the measure of exposure and effect was a comparison of modeled tissue data to dietary toxicity reference values (TRVs).

3.4.4.2 Exposure and Effects Assessment

The factors describing chemical behavior in the food chain were a water-to-tissue parameter, a sediment-to-water parameter, and a sediment-to-biota parameter. The parameters describing organic chemical behavior in the food chain were used in this evaluation were Kow, Koc, and a biota-sediment accumulation factor (BSAF). The parameters describing metals behavior in the food chain were used in this evaluation were a BCF, Kd, and trophic transfer factor (TTF).

The parameters used in the Trophic Trace model to define the environment at the Rhine Channel were surface water temperature, TOC in sediment, and the concentrations of COPCs in sediment and surface water. The water temperatures used in the model were the averages reported by NMFS at Balboa, California, and Newport Beach, California, respectively. The TOC values used in the model were the minimum, mean, and 95 percent upper confidence level (95% UCL) of the mean concentrations measured in 2002 in the surface sediments in Rhine Channel (Bay and Brown 2003). The freely dissolved surface water concentrations of COPCs were calculated by the model from the sediment and TOC data using equilibrium partitioning; however, site-specific surface water data were available and were applied for this evaluation. Table 7 presents the sediment and surface water concentrations applied in the modeling effort.

Organism parameters applied in the model included percent lipids for invertebrates; percent lipids, weight, food prey items and percent of diet, and site use factors for fish; and weight, food ingestion rate, food prey items and percent of diet, and site use factors for wildlife. These values were selected based on available information from various life history data sources and attempted to approximate the biological and ecological features of the species likely to be found at the site. Where available, site specific or regional data were applied, including site-specific lipid content data for the forage fish.

The selection of COPCs was based on the screening of sediment surface data chemistry (top 10 cm) against established sediment quality guidelines (SQGs). While a number of chemicals in Rhine Channel surface sediments exceeded the SQGs established for the protection of benthos, a more stringent screen was applied to determine the primary bioaccumulative COPCs. Specifically, the sediment data were compared to the bioaccumulation trigger values established by the Puget Sound Dredged Material Management Office. Chemicals with a maximum concentration more than one-half the bioaccumulation trigger value (copper, mercury, selenium, DDE, and total PCBs) were retained for further assessment in this focused EcoRA.

Dietary and tissue-based TRVs for the ROC-COPC pairs were taken from readily available data sources including the Corps Environmental Residue Effects Database and EPA-reviewed final risk assessments at other contaminated sediment sites around the United States. Where possible, no observable apparent effects levels (NOAEL) and lowest observable apparent effects levels (LOAEL), obtained from laboratory studies, were used to provide a better evaluation of TRV uncertainty. Where more than one relevant TRV was available for a given chemical, the lowest, most conservative value was selected.

3.4.4.3 Risk Characterization and Uncertainty Evaluation

Risk to the ROCs from exposure to the COPCs in Rhine Channel sediments was assessed using toxicity quotients (TQs). Trophic Trace provided a range of TQs based on the fuzzy math assessment of uncertainty using the minimum, mean, 95% UCL of the mean, and the maximum of the sediment and TOC concentrations. This range of values provides a method to assess the uncertainty in the risk estimates. For the risk characterization, the 95% UCL sediment concentration was used to provide the maximum reasonable exposure estimate. The 95% UCL is likely a conservative exposure estimate because the area-weighted COPC concentrations in the Rhine Channel sediments are lower. A summary of the modeling results are presented in Table 8.

For the fish, cormorant, and seal ROCs, LOAELs were used as the benchmark to assess risk. For brown pelican, a threatened or endangered species, NOAELs were used as the risk benchmark to ensure that individuals would be protected.

Uncertainties in the problem formulation and the exposure and effects measure have the potential to affect the conclusions of a risk assessment. The selection of COPCs was based on previous screening results. It is unlikely that the selection of COPCs would result in changes to the risk conclusions. The receptors evaluated for the EcoRA were selected to represent species with the greatest likelihood of having a complete pathway to sediment-associated COPCs. To provide a conservative evaluation of risks, the TRVs for this assessment were the lowest values for the relevant organisms and endpoints that were available in the literature. As such, some of the estimates may represent the lower range of potential risks for each exposure group. It is unlikely that species not represented have greater exposure potential or are significantly more sensitive than the species evaluated. Uncertainties for exposure measures are discussed below for the species evaluated.

3.4.4.3.1 Fishes

For the metals, the BCF model approach was applied to estimating dietary or tissue-based exposures. It is important to note that, for metals, it is assumed that the bioavailable fraction of sediment associated metals is represented by the calculated, or measured, dissolved metals concentration in the water. In order to estimate the metal concentration in tissue, the water concentration is multiplied by the BCF. Relative to the modeling of non polar organics, the BCF approach is more uncertain. However, the BCF approach used conservative BCF values (USEPA 2004). For this reason, in addition to the model results, two additional, site-specific, lines of evidence were considered for evaluating risk to fish from sediment associated metals. These additional lines of evidence the measured surface water and sediment-water interface concentrations (SCCWRP 2004a) and the measured fish tissue burdens (SCCWRP 2004b).

For copper, the modeled dietary exposure using the 2X water value (which approximates the measured dissolved water column concentration at Station NB3), exceeded the dietary NOAEL value. The modeled dietary exposure using 4X water value exceeded the LOAEL. While the 4X copper value may be greater than actual copper concentrations in Rhine Channel, it is important to note that the measured surface water concentrations exceed the acute and chronic marine ambient water quality criteria (AWQC). Overall, it appears that there is a risk to fishes in the Rhine Channel from copper. The fact that copper measured at the sediment-water interface in the Rhine Channel is ten times higher than that measured at station NB10 indicates that the Rhine Channel sediments are a possible source.

For mercury, the BCF approach was coupled with a trophic transfer factor to estimate tissue burdens in fish for comparison to tissue-based TRVs. The modeled tissue burden using the 2X water value, exceeded the dietary NOAEL value. The modeled dietary exposure using 4X water value exceeded the LOAEL. However, for mercury, the values measured by SCCWRP (2004a) were below detection limits and the detection limits were substituted into the exposure model. The mercury detection limits were well below AWQC values. Mercury tissue concentrations measured in forage fishes collected from near the mouth of the Rhine Channel (SCCWRP 2004b) were also below the tissue-based TRVs. Overall, there does not appear to be a significant risk to fishes in the Rhine Channel from mercury.

For selenium, none of the modeled dietary exposure levels exceeded the NOAEL. The measured water column and sediment-water interface selenium concentrations are well below the AWQC values. In addition, selenium concentrations measured in forage fishes were below the dietary TRV values. Overall, there does not appear to be a significant risk to fishes in the Rhine Channel from selenium.

For DDE, none of the modeled tissue burden exposure levels exceeded the NOAEL. Overall, there does not appear to be a significant risk to fishes in the Rhine Channel from DDE.

For PCBs, the modeled tissue burden exposure levels based on the maximum PCB concentrations exceeded the NOAEL for killifish, turbot, and halibut. Overall, there does not appear to be a significant risk to fishes in the Rhine Channel from PCBs.

3.4.4.3.2 Wildlife

For harbor seal, the NOAEL for PCBs was exceeded for the tissue burdens based on the mean sediment concentration. Because all of the LOAEL TQs were less than 1, it is unlikely that Rhine Channel sediments pose a risk to harbor seals. Although there is some uncertainty in the TRV that was used because it was based on Mustelid (otter) toxicity, mustelids are among the most sensitive species to PCBs. No other chemicals had TQs greater than 1 for harbor seal. The site use factor (SUF) for harbor seal was 0.05, although foraging areas are likely greater than 500 hectares (ha). This source of uncertainty is acceptable to ensure that risk estimates are conservative. Overall, there does not appear to be a significant risk to seal in the Rhine Channel from any of the bioacumulative COPCs assessed herein.

For adult cormorant, the NOAEL TQs was exceeded for the 95% UCL DDE concentration; all DDE LOAEL TQs were less than 1. For cormorant eggs, the minimum DDE concentrations resulted in a NOAEL TQ greater than 1 and the 95% UCL DDE and concentration had a LOAEL TQs greater than 1. For PCBs and adult cormorant, the NOAEL TQs was only exceeded for the maximum PCB concentrations; all LOAEL TQs were less than 1. For cormorant eggs, the mean PCB concentrations resulted in a NOAEL TQ and LOAEL TQs greater than 1. Because the LOAEL TQs for the 95% UCL for PCBs and DDE were greater than 1 for cormorant eggs, risk to cormorant reproduction is possible due to bioaccumulation of these compounds from the sediment to fish tissue.

For cormorant and metals, the BCF approach was coupled with a trophic transfer factor to estimate tissue burdens in fish for comparison to the dietary-based TRVs for birds. For mercury, the modeled tissue burden, using the 1X measured water value, exceeded the dietary NOAEL value. The modeled dietary exposure using 4X water value exceeded the LOAEL. However, for mercury, the values measured by SCCWRP (2004a) were below detection limits and the detection limits were substituted into the exposure model. The mercury detection limits were well below AWQC values. Mercury tissue concentrations measured in forage fishes collected from near the mouth of the Rhine Channel (SCCWRP 2004b) were also below the dietary-based bird LOAEL (HQ = 0.07) [2]. Overall, there does not appear to be a significant risk to cormorant

[2] Based on maximum mercury whole body forage fish concentration of 0.02 mg/kg (SCCWRP 2004b), the estimated dose to cormorant is 0.0059 mg/kg bw day. A fish tissue mercury concentration of approximately 0.31 mg/kg would be required to exceed the mercury LOAEL for birds.

from bioaccumulation of mercury from the sediment to fish tissue. Neither copper nor selenium TRVs were exceeded for cormorant.

As noted above, brown pelican is a threatened or endangered species and therefore NOAELs were used as the risk benchmark to ensure that individuals would be protected. For adult brown pelican, the NOAEL TQs was exceeded for the maximum DDE concentrations; all DDE LOAEL TQs were less than 1. For brown pelican eggs, the mean DDE concentrations resulted in a NOAEL TQ greater than 1 and the maximum DDE and concentration had a LOAEL TQs greater than 1. Because the NOAEL TQs for the 95% UCL for DDE were greater than 1 for pelican eggs, risk to brown pelican reproduction is possible from exposure to DDE associated with the Rhine Channel sediments. There is uncertainty associated with the DDE TRV selected for assessing adult brown pelican due to the fact that the value was derived from uncontrolled field studies and that contaminants in addition to DDE may have been present in prey items.

For PCBs and adult pelican, all NOAEL TQs were less than 1. For brown pelican eggs, the mean PCB concentrations resulted in a NOAEL TQ and LOAEL TQs greater than 1. Because the NOAEL TQs for the 95% UCL for PCBs were greater than 1 for pelican eggs, risk to brown pelican reproduction is possible from exposure to the Rhine Channel sediments. None of the metals TRVs were exceeded for brown pelican. The SUF for brown pelican was 0.03, based on a conservative estimated foraging area of 1,000 ha. Although brown pelican rookeries are on the Channel Islands, and foraging areas are likely greater than 1,000 ha, this source of uncertainty is acceptable to ensure that risk estimates are conservative. Overall, it appears that DDE and PCBs in Rhine Channel sediment may contribute incremental risk to the reproduction of brown pelican due to bioaccumulation of these compounds from the sediment to fish tissue.

3.4.4.4 Risk Summary and Conclusions

This risk assessment evaluated the potential for adverse effects to fishes, birds, and marine mammals from Rhine Channel sediments under existing conditions. In the risk characterization, exposure and effects data were compared for the seven ROCs and five COPCs. The exposure of the ROCs to sediment-associated COPCs was evaluated for direct contact or ingestion of sediments and surface water, as well as food chain transfer of contaminants from sediment and/or water → invertebrates → forage species → piscivorous species as generally framed by the Trophic Trace model. Bioaccumulation modeling of the COPCs was used to evaluate whether food chain accumulation would result in tissue burdens or dietary doses greater than selected TRVs. Table 8 summarizes the results that were obtained based on reasonable and conservative exposure estimates.

For all fish species, dietary exposure to copper indicated potential adverse effects to survival, growth, or reproduction. In addition, it is important to note that copper measured in Rhine Channel surface water samples exceeded AWQC acute and chronic values. Based on a weight of evidence approach that included comparison of the modeling results to measured surface water and tissue burdens of mercury and selenium, there does not appear to be a significant risk to fishes in the Rhine Channel from these metals.

For cormorant and pelican adults, no risk was indicated from any of the COPCs. However, for pelican and cormorant eggs, the TRVs were exceeded for PCBs and DDE, indicating potential risk to the reproduction of these birds. However, it is important to note that the evaluation was conservative and that there is substantial uncertainty around the bird exposure and effects estimates data that were applied. Overall, DDE and PCBs in Rhine Channel sediment may contribute incremental risk to the reproduction of cormorant of brown pelican due to bioaccumulation of these compounds from the sediment to fish tissue.

3.5 Estimated Volume of Impacted Sediment

The 16 sediment cores sampled in November 2004 showed clear stratification between native materials and overlying recently deposited sediments. Based on the site characterization described in the previous sections, it appears that the interface between recent sediment and underlying native sediment corresponds well with the vertical extent of chemically impacted sediment. The total volume of recent, impacted sediment was estimated from the depth to native sediments measured in each of the cores and in a series of sediment probes that were advanced near the sides of the channel (see Figures 2A and 2B). The resulting estimate of recent, chemically impacted sediment is approximately 68,000 neatline cubic yards, as tabulated in Table 9,. The entire water surface area of the Rhine Channel was accounted for in this calculation, including sediments along the perimeter seawalls.

In order to remove this projected volume of sediment, the information gained from coring would need to be converted to a dredging plan, in which the channel would be subdivided into discrete areas, each with its own representative (and conservatively selected) depth to dredging. The resulting 'neatline' volume is an estimate of the actual volume required for dredging, and includes an additional amount of sediment above the volume of impacted sediment, to make sure that all impacted sediment is fully removed. We have assumed that this additional volume would be on the order of about one foot, averaged throughout the channel, which adds another 28,000 cy to the volume estimate.

Consideration of equipment tolerances requires provision of an overdredging allowance for dredging operations. At this site a six-inch allowable overdredging depth is accounted for; this adds approximately 14,000 cy more material. Thus, the total estimated volume of sediment to be dredged or treated from the Rhine Channel as calculated from the data on Table 9, is as follows:

68,000 cy of contaminated (chemically impacted) sediment as a neatline volume

28,000 cy of additional volume to account for dredge plan design

14,000 cy of allowable overdredging

110,000 cy assumed total sediment volume from the Rhine Channel

This sediment volume is based on limited site information and does not account for design-level detail that would be included when devising an actual dredging plan. Therefore, the volume may change during design and/or based on further analysis of the sediments in the native layer and clean up level criteria.

4 SITE CONDITIONS AND DESIGN CRITERIA

4.1 Site Layout and History

The Rhine Channel is located in lower Newport Bay (Figure 1) adjacent to Lido Island. The area was historically a small inlet in the larger marsh system of Lower Newport Bay. In 1918, the first boatyard was built on the channel. A fish cannery was built in 1919, but was used predominately after 1935. The dredging of Lido Channel South occurred in 1920, with large scale dredging of Lower Newport Bay occurring in 1934 – 35 to provide safe harbor navigation. During the 1940s and 1950s the channel supported boat building activities for both the US Navy and the Mexican Navy during World War II and the Korean War. The boatyards produced midsize boats, mainly mine sweepers, subchasers, and rescue boats in the 45 to 135 foot length range. In 1964, there were 19 boatyards operating in the Lower Bay. Currently six boatyards operate along the Rhine Channel. The boatyards are currently regulated by General Waste Discharge Requirements issued by the State Water Board.

A review of available site mapping information (City of Newport Beach 2005) indicates that there are currently seven storm drains with outfalls that discharge into the Rhine Channel. The existing stormlines and outfalls are shown on Figures 2A and 2B, and are located as follows (including nearest project stationing, for reference):

- Head of the channel, from below Lido Park Drive (Station 0+00)
- West side of channel, at 30^{th} Street (Station 2+00)
- West side of channel, at 29^{th} Street (Station 4+50)
- West side of channel, at Villa Way (Station 8+50)
- West side of channel, at 26^{th} Street (near Station 12+00)
- West side of channel, at 21^{st} Street (Station 19+00)
- West side of channel, at 19^{th} Street (Station 23+00)

This may not be a complete and updated list; other, smaller storm drains and outfalls may also be present at the site. Current and past businesses located within the drainage basin for these storm drains include a metals plating facility and Schock Shipyard (near or along the 29^{th} Street storm drain), Balboa Shipyard (near the 26^{th} Street storm drain), South Coast Shipyard (storm drain connection not identified), Sea Spray Shipyard (near the 21^{st} Street storm drain), and Newport Shipyard (on the east side of the channel; storm drain connection not identified). Historic practices at the boatyards and stormwater runoff are the most likely sources of pollutants in the Rhine Channel, although a thorough source characterization study has never been undertaken.

4.2 Site Topography and Bathymetry

The Rhine Channel is approximately 2,300 feet long and consists of two reaches separated by a slight bend in the channel alignment. The outer reach (Reach 1; depicted on Figure 2A) extends from the mouth of the channel to the bend, and is oriented to the northwest. The inner reach (Reach 2; depicted on Figure 2B) extends from the bend in the channel to the head of the channel, and is oriented to the north.

A bathymetric survey of the Rhine Channel was conducted in the fall of 2004 by Gahagan and Bryant Engineers. The average mudline elevations throughout the channel are between -10 and -12 feet mean lower low water (MLLW). There are three distinct depressions in the channel bottom that can be seen on Figures 2A and 2B. At the north end of Reach 2 in the turning basin (near sample location RS04-02), the elevation reaches -14 feet MLLW. Another depression exists near the bend of the channel in Reach 1 adjacent to sample location RS04-12. This depression extends to -20 feet MLLW. A third depression can be found near the entrance to the channel in Reach 1. The elevation of this depression is -17 feet MLLW. These depressions appear to be the result of ongoing erosion of bottom sediments by propeller wash forces from vessel activity.

The floating docks and piers that line the channel interfered with the bathymetric survey equipment. Therefore, the bottom survey depicted on Figures 2A and 2B shows only the contour lines in the middle of the channel. The elevations underneath the floating docks and piers are assumed to be consistent with the surveyed portions. Additional surveying may need to be conducted in order to prepare accurate design documents.

4.3 Conditions of Marine Environment

The Rhine Channel is connected to Newport Bay and beyond this, the Pacific Ocean, and thus is subject to tidal fluctuation. Tides in Newport Bay have a mean range of 2.75 feet, with the upper bound for 2005 being 8.85 feet MLLW and the lower bound -3.34 feet MLLW. The tidal fluctuations experienced in the Rhine Channel are somewhat delayed and muted from those measured at the entrance to Newport Bay, owing to the channel's location within the Bay. The channel is not exposed to any additional currents of any significance since it does not convey any river flow, and is relatively protected from winds by the adjacent land areas.

Because of the historic industrial site use, a side scan sonar survey was conducted in the fall of 2004 by Gahagan and Bryant Engineers to identify existing debris in the channel. Results of the survey, presented in Appendix E, detected 87 pieces of apparent debris. The exact size or nature of the debris is unknown. On the west side of Reach 1 near sample location RS04-10 is a debris field that contains several objects, possibly fish trawler doors. This field is adjacent to a sinker lift which indicates that the objects may have come from loading and offloading of vessels and equipment.

4.4 Physical Characteristics of Sediment

Site sediments were observed during coring and are described as primarily grey, with some black and brown silts, clays, and fine-grained sands. The sediment typically had no discernable odor. The recent, surficial sediment was readily penetrated by the core, with a fairly abrupt transition to firmer, underlying native material.

Sediment samples obtained from the 16 core sample stations were submitted to various physical characterization tests, including moisture content, bulk density, grain size distribution, and Atterberg Limits.

Moisture content was measured on five samples, which had an average moisture content of 77 percent by weight. The values ranged from 40 to 117 percent. Bulk density, also measured on five samples, averaged 95.6 pounds per cubic foot (pcf), and ranged from 86 to 107 pcf. These are fairly typical values for shallow and recently deposited marine sediments.

Forty three samples were analyzed for grain size distribution, including hydrometer testing to identify the components of the fine materials fraction. On average, the material consisted of 36 percent sand (by weight) and 64 percent fines (primarily silt, with a lesser amount of clay), with a trace of gravel detected in a few samples. Overall, the material is classified as sandy silt. A few individual samples consisted entirely of sand or entirely of fines.

The fines fractions from 16 selected samples were tested for Atterberg Limits, which are physical index properties that characterize the plasticity of the material and thus its behavior when disturbed. From these samples the average Liquid Limit (LL) was 41.5 percent, and the average Plastic Limit (PL) was 20 percent, for a Plasticity Index (the difference between the LL and PL) equal to 21.5 percent. This classifies the fines content of the sediment as CL, a low plasticity clay, which is consistent with the results of grain-size distribution testing described above. The moisture content (77 percent average, mentioned above) is well above the LL, indicating that the material is in a state of high moisture and is currently moldable and flowable.

A field vane shear testing device was used to measure shear strength of the sediments at various depths for seven of the coring locations. Altogether a total of 20 field vane tests were performed, using a 65-millemeter (mm) diameter vane. The field vane consists of a crossed pair of thin steel fins (the "vane") attached radially to the end of a rod; the rod is used to push the fins into the sediment to a selected depth. Torsion is then applied to the rod until the fins shear the sediment, allowing the vane to turn. A torsion spring is used to measure the force applied to the rod at the point of shearing, and this value can then be converted to an apparent shear strength of the sediment.

For the 20 field vane tests performed, the average computed shear strength was 25 pounds per square foot (psf; 0.01 tons per square foot). The shear strength was seen to increase with depth; measurements conducted 6 inches below mudline indicated a shear strength of 4 to 13 psf, while tests done 18 inches below the surface ranged from 33 to 66 psf. All of these results indicate that the sediment is very soft.

4.5 Shoreline Structures

The Rhine Channel shoreline has a total linear footage of roughly 5,000 feet and is completely developed with residential housing and commercial businesses. The interior perimeter of the channel consists mainly floating docks and piers. There are at least two boat ramps and several lifts that are operated by marine service businesses. Most of the shoreline is occupied by concrete seawalls, which are mainly concrete slab bulkheads with a concrete apron. Less than 400 feet of the Rhine Channel shoreline is rock armor, beach, or natural slope.

In November 2004, a visual review of structural components and existing conditions of the Rhine Channel was conducted, and the results of this review detailed in a technical memorandum dated December 2004 (Appendix C). This information was subsequently used in estimating the footage of existing bulkheads that may require repair or replacement should dredging occur along the wall face.

4.6 Site Access and Constraints

Upland site access to the Rhine Channel is severely limited as a result of intense development along the shoreline of the channel. The only direct access point for staging of upland equipment and supplies is located along Lido Park Drive next to the Cannery Restaurant (Figure 2B). Other access points for upland staging are limited to private property owned by the boatyards along the eastern shore of the channel.

Site access via the water is permissible for small to moderately sized vessels. Water depths range from 8 to 15 feet throughout the channel. Channel widths (the distance between bulkhead lines along opposite shores) are approximately 450 feet in Reach 1 and approximately 200 feet in Reach 2 (from the 25th Street drain to the Cannery).

Other site constraints include the presence of multiple private boat slips and a dry stack boat storage business along the Rhine Channel. Any site construction would require accommodating vessel traffic in and out of the channel, as well as temporary relocation of multiple in-water vessels currently residing at adjacent docks. In addition, several single and multi-user residential structures are located along and in the vicinity of the channel, which will require construction activities to be conducted primarily during working business hours.

5 IDENTIFICATION AND SCREENING OF REMEDIAL ACTIONS

In this section, various options for sediment remediation are presented and screened for their overall feasibility for application to the Rhine Channel site. A subset of remedial actions are carried forward to the more detailed evaluation, presented in Section 7.

5.1 Natural Recovery

Natural recovery of chemically impacted sediments is a process by which chemical concentrations in the upper sediment layers are reduced over a period of time, usually several years, following significant reduction or elimination of contaminant sources (USEPA 1989). Sediment quality improves through a combination of natural processes (e.g., biodegradation, sediment accumulation and mixing, diffusive losses) and source control activities. Monitoring is necessary to confirm that recovery is taking place.

Although natural recovery can be a preferred remedial strategy for marginally contaminated sediments, chemical concentrations measured in the Rhine Channel would necessitate a relatively long period of natural recovery, especially since there are no known sources of clean sediments entering the study area that could assist in the process. Natural recovery also does not allow for potentially deepening of the channel to increase draft depths in the future because the material currently in place cannot be disturbed. As a result, natural recovery has not been carried forward to the detailed alternatives evaluation.

5.2 Thin-Layer Capping (Enhanced Natural Recovery)

Thin-layer capping—placing 15 to 30 cm of clean capping material (e.g., sand or sediment) over chemically impacted sediments—is a proven means of aiding in the natural recovery process. The objective of thin-layer capping is not to isolate these surface sediments, but to augment the natural sedimentation rate, and thus the process of natural recovery. Natural processes, primarily bioturbation, will mix the sand with the underlying material and thereby reduce chemical concentrations in the biologically active zone and reduce associated adverse effects with minimal disruption of the existing benthic community. Chemical degradation also factors in to natural recovery of contaminated sediments. For this reason, thin-layer capping is often termed “enhanced natural recovery.” It can be a viable alternative in areas with surface sediment concentrations that require action but have concentrations higher than those expected to recover naturally.

Again, as for natural recovery, chemical concentrations measured in the Rhine Channel are likely to exceed those that allow expedient use of thin-layer capping. Furthermore, vessel traffic and draft requirements in the channel preclude the addition of materials to the current mudline. Therefore, thin-layer capping has not been carried forward to the detailed alternatives evaluation. It may, however, be considered for use at the site in combination with another remediation alternative such as dredging. Occasionally, dredging results in undesirable residual sediment concentrations following construction activities. In the event that this occurs, options include additional passes of the dredge equipment or spreading a thin layer of clean sand onto the new surface to help aid the recovery process.

5.3 Engineered Cap (Chemical Isolation)

Construction of an engineered cap involves placing capping materials, typically composed of clean sand, sand and gravel, or armoring rock, over problem sediments to isolate them from the environment. The thickness of an engineered cap is typically greater than or equal to 1 foot and is designed to physically isolate the impacted sediments from the overlying water column and from biological activity. Palermo et al. (1998), for example, have demonstrated that a 45 cm (1.5 foot) thickness of clean silty sand can isolate the majority of benthic organisms from contaminated sediments, preventing bioaccumulation of contaminants, and effectively preventing contaminant flux for the long term. Long-term (up to 10 years) monitoring is typically used to ensure that the engineered cap has successfully isolated the contaminants of concern.

Because engineered cap placement raises the elevation of the mudline, this approach is typically only used in areas where navigational depths are not an issue. The Rhine Channel's current water depth requirements for vessel use cannot accommodate any reduction in water depth, so placement of an engineered cap would be inconsistent with current and future site uses. This also rules out a combined approach of partial dredging followed by capping, since the dredge depth would be less than the engineered cap thickness in many areas, thus incurring a loss of water depth. Furthermore, an engineered cap would likely require armoring, because it could be compromised by erosional forces from vessel operations and propeller wash. For these reasons, and at collective request of the TAC members, construction of an engineered cap has not been carried forward to the detailed alternatives evaluation.

5.4 In-situ Treatment

In-situ treatment of chemically impacted soil or sediments involves applying chemical admixtures, binding agents, or physical modifications directly to the in-place soil or sediments. The intent of the treatment is to modify the physical and chemical properties of the soil or sediment in such as way as to prevent chemical constituents from entering or being in contact with the physical environment. Examples of in-situ treatment approaches include in-place compaction, soil freezing, vitrificaiton, vacuum extraction, or direct application of cement.

While in-situ treatment technologies are under development or have been used for upland soils, these approaches are either untested on marine sediments or (in the case of cement mixing) are not effectively implemented over a large area covered by a relatively thin layer of chemically impacted sediment. Furthermore, in-situ treatment does not address the goal of deepening the channel to increase draft depths in the future, unless the treated material is removed and disposed off-site, which would essentially double the remediation costs. As a result of these disadvantages, this option has not been carried forward to the detailed alternatives evaluation.

5.5 Removal (i.e., Dredging)

Sediments that exceed chemical cleanup levels can be physically removed by dredging and transported to a permanent disposal location. Dredging can be accomplished either by mechanical or hydraulic methods, depending on such factors as site access constraints, availability of adjacent upland space, and the final disposal destination. Dredged sediment can be loaded or pumped onto barges, or onto an adjacent upland space, and transported via barge, truck, rail, or pipeline to a final disposal facility.

The actual vertical extent of contaminated sediment on a site is defined by a contaminated "neatline." This neatline theoretically denotes the bottom of contaminated sediment throughout the site, and defines a contaminated neatline volume which represents the actual in-situ volume of the contaminated sediments. Dredging is accomplished to a series of specified elevations or depths depicted on a dredge plan, which is designed to encompass the contaminated neatline and therefore the complete vertical extent of contaminated sediment. To help ensure that the all the neatline volume is removed, in many areas the dredge plan will require dredging to greater depths than the neatline. Therefore, dredging to these required elevations will remove a volume of sediment that exceeds the contaminated neatline volume by some amount. In addition, contractors are typically allowed to remove a specified additional thickness, or overdredging allowance, which increases the likelihood that the contaminated volume is fully removed, while accounting for the accuracy of the dredging equipment and its positioning. Specified overdredging allowances for projects of this type are usually in the range of 6 to 12 inches.

After dredging is completed to the specified elevation, a series of confirmational samples are taken from the newly exposed substrate to evaluate whether the remaining sediments contain concentrations above site cleanup levels. It is fairly common at this stage to find that some amount of “residual” contamination is still present on the channel bottom after the first round of dredging is completed; in some cases this warrants an additional dredging pass by the contractor or the placement of a thin layer of cap material (see Section 5.2).

The following paragraphs discuss hydraulic and mechanical dredging methods. Various alternatives for sediment disposal are discussed in Section 5.6.

5.5.1 Hydraulic Dredging

Hydraulic dredging involves the removal of sediments using a cutterhead or suction dredge, which creates a sediment/water slurry that is pumped to the surface. The slurry can then be routed via a floating pipeline either to a nearby disposal site, settling pond, barge, or hopper on the dredge itself.

The sediment/water slurry that is generated by hydraulic dredging typically contains only 5 to 20 percent solids by weight. The large amount of water entrained during the hydraulic dredging process requires handling and treatment, often accomplished in a landside settling basin of sufficient size to handle the volume of slurry produced. Decant water then must be treated prior to its discharge. Altogether this process requires a considerable amount of open upland space adjacent to the site. This poses a potential complication for the Rhine Channel project because land areas adjacent to the project site have very restricted space available for a receiving basin for hydraulically dredged slurry.

Another potential dewatering option would be to run the slurry through mechanical dewatering devices such as hydrocyclones and/or filter presses to reduce the dredged sediment's water content. Hypothetically, such an approach could reduce the amount of upland space needed, although application of such dewatering approaches is complex and not always effective. . Furthermore, the costs of mobilizing and running the dewatering equipment is likely to offset the savings in upland storage area, and treatment of discharge water will still be necessary.

Based on these factors, hydraulic dredging is not considered a likely method for dredging at this site, and is not carried forward to the detailed alternatives evaluation.

5.5.2 Mechanical

Mechanical dredging is typically accomplished using a digging bucket (e.g., clamshell), which is deployed from a derrick crane mounted on a floating barge. In some cases, site constraints dictate the use of more specialized dredging equipment, including backhoe dredges (excavators), dragline dredges, dipper dredges, and bucket ladder dredges; although, these methods are not necessarily as available as the bucket dredge, and may be less desirable for dredging contaminated sediments.

Mechanical bucket dredges are used by many contractors in southern California, and the equipment can typically be readily available for projects such as this. Furthermore, mechanical dredging is commonly used and has been successful for sediment remediation projects similar to this one. Mechanical dredging of Rhine Channel sediment will be carried forward to the detailed alternatives evaluation.

5.6 Disposal Options

5.6.1 Open-Water Disposal

Open-water disposal of sediment entails transportation of the dredged material via a barge to a permitted open-water disposal site (such as the LA-3 disposal site) administered by the U.S. Army Corps of Engineers (Corps). Sediments must undergo testing to determine whether they are chemically suitable for open-water disposal, in accordance with the protocols described in the "Green Book," developed by the USACE and EPA (1991).

Chemical sampling completed at the Rhine Channel (Section 3) indicates that dredged sediment will have chemical concentrations too high to meet requirements for open-water disposal. Furthermore, previous bioassay testing conducted by SCCWRP has showed significant toxicity associated with the Rhine Channel sediments. Therefore, this disposal option is not carried forward to the detailed alternatives evaluation.

5.6.2 Upland Landfill

Upland disposal facilities include either existing local, municipal landfills or landfills dedicated solely to the project. A regional out-of-state landfill would be needed if the sediment were determined to be California Hazardous Waste, which is not expected for the majority of the material. Upland disposal facilities accept sediment based on their chemical characterization, and typically require that the material pass the "paint filter" test, which would require dewatering of dredged sediments prior to their transport to the disposal facility. This in turn requires suitably sized, waterfront upland staging area(s) for the offloading and dewatering process.

Dewatering can be accomplished by stockpiling dredge sediment for a suitable length of time and can also be accelerated by adding cement or lime admixtures to bind the water in the sediments. Such admixtures are often a cost-effective alternative because they significantly lessen the demand for available stockpiling area and speed up the disposal process.

It is expected that the Rhine Channel sediments will qualify for disposal at local Class III landfills. An alternative to typical landfill disposal is for the material to be beneficially used as Alternate Daily Cover (ADC) material within the landfill. In addition to the obvious benefit of reusing the material instead of simply treating it as waste, the landfills may offer a waiver or reduction in their typical tipping fees. The potential for using dredged sediments as ADC is subject to further testing and evaluation of the sediments, and is contingent on landfill demand for imported ADC materials.

Disposal at an upland landfill appears to be a feasible option, with specific disposal locations yet to be determined. This disposal option has been carried forward to the detailed alternatives evaluation.

5.6.3 Confined Aquatic Disposal (CAD)

Disposal in a Confined Aquatic Disposal (CAD) area involves placing the dredged sediment into a submarine excavation made in clean native sediments either on the project site or in its vicinity, and covering the filled excavation with a layer of clean sediments or sand to confine it from the marine environment. The material that is excavated to create the hole or depression is typically a clean material that can be disposed or reused off-site, with significantly lower disposal costs because it is not chemically impacted. CAD disposal is an approach that has been successfully permitted and constructed in California and in other states.

The feasibility of a CAD disposal approach is largely a function of the availability of space that is of suitable size to hold the volume of sediment needing disposal. Assuming that dredging the Rhine Channel will generate 110,000 cy of sediment, a 20-foot-deep excavation would need to be on the order of 500 feet by 500 feet in size to hold the dredged material (including allowance for a 5-foot-thick clean cap on top and a few feet of settlement of the placed sediment within the CAD). The Rhine Channel itself is too narrow to accommodate such an excavation. However, the portion of Newport Bay immediately beyond the mouth of the channel is suitably spacious, although allowance would need to be made for the use of this area for temporary vessel berthing.

Because disposal in a CAD is a proven design approach which has been successfully utilized for similar projects, and because the project area can conceptually accommodate a CAD, this disposal option has been carried forward to the detailed alternatives evaluation.

5.6.4 Nearshore Confined Disposal Facility (NCDF)

Another frequently used option for dredged sediment disposal is a constructed Nearshore Confined Disposal Facility (or NCDF). A NCDF is a constructed enclosure that is designed specifically for the purpose of containing dredged sediment and physically confining it from the surrounding environment. The enclosure is typically created by building a specially engineered berm or wall across the mouth of a slip or inlet, which is then filled with the dredged sediment and then capped with a suitable thickness of clean material.

This disposal option requires up-front costs for construction and site preparation. In many cases the NCDF may provide future site use benefits to the site owner by creating additional usable land space.

Off-site NCDF construction. NCDFs have been used on several west coast projects, and have successfully undergone detailed evaluation by EPA and other regulatory agencies. Recent examples of permitted and constructed NCDFs include a number of terminal facility upgrades over the last decade by the Port of Los Angeles (POLA) and Port of Long Beach (POLB), the Slip One and Milwaukee Waterway NCDFs at the Port of Tacoma, and the Pier 90/91 NCDF at the Port of Seattle. In the past, such projects have provided significant volume capacity for disposal of contaminated sediments from Port projects as well as from other local dredging activities. Although, at this time, there are no known imminent plans for new NCDF developments at POLA or POLB, such a project could provide a feasible and environmentally desirable disposal option for Rhine Channel sediments. Disposal in an off-site NCDF, therefore, has been carried forward to the detailed alternatives evaluation, contingent on the identification of such a facility in the future.

On-site NCDF construction. The suitability of the Rhine Channel area has been evaluated for possible on-site construction of a NCDF. A theoretical NCDF on the Rhine Channel would be developed by installing a new bulkhead waterward from the existing bulkheads, and filling between the old and new bulkheads with the dredged sediment (potentially after stabilizing the sediment with a cement admixture).

However, there are several significant hurdles to creating a usable and cost-effective NCDF on-site. One limitation is the fact that the site offers little available volume capacity for sediment confinement. A new bulkhead constructed for NCDF development would have to remain inside of the channel's federally mandated U.S. pierhead line. This line is typically only 15 to 20 feet out from the existing site bulkheads, leaving little room for placement of dredged sediment. There is room between the existing concrete bulkhead and the designated U.S. bulkhead line to create a thin NCDF that could contain approximately 6,000 cy of material. Alternatively, lining the entire eastern side of Reach 2 with a new NCDF bulkhead built outward from the shore, would produce a maximum of only 20,000 cubic yards of storage capacity; which is a fraction of the total amount of sediment projected for dredging (110,000 cy). Less extensive NCDFs, or NCDFs that make use of possible bulkhead upgrades by current site owners, provide even less storage capacity (no more than 10,000 cy).

Another limitation is that NCDF construction would conflict with site usage. A new bulkhead built along the channel pierhead line would preclude installation of finger piers outward from the bulkhead, since they would infringe on the defined navigational channel width. This would significantly reduce the amount of vessel berthing that is available along the sides of the channel, wherever such bulkheads are located.

Overall, the cost of the construction and disposal of the remaining sediment (which could be more than 100,000), the permitting issues, and the future site use restrictions outweigh the benefits of creating an on-site NCDF with limited disposal space. As a result of these hurdles, construction of a NCDF on-site at the Rhine Channel has not been carried forward to the detailed alternatives evaluation.

5.6.5 Treatment/Reuse

In some cases, dredged sediments are, or can be made, suitable for beneficial reuse, for example as construction fill, habitat restoration, or beach nourishment. Various methods of treatment, such as addition of lime, cement, or other additives, can be used to improve the physical and chemical characteristics of the sediment to make it better suited for reuse. Such beneficial reuse, however, is typically contingent on the material being relatively free of contaminants. With the possible exceptions of sediment use as ADC for a local landfill (as is mentioned in Section 5.6.2), or as fill within a Port capital improvement NCDF (as is mentioned in Section 5.6.4), the Rhine Channel sediments are not likely to be acceptable for beneficial reuse in the area. Therefore this option has not been carried forward to the detailed alternatives evaluation (beyond the ADC and Port NCDF options, described previously).

5.7 Screening of Remedial Actions

Based on the previous discussion, the following remedial technologies have been evaluated and either carried forward to the detailed alternatives evaluation, or screened out:

Remedial Alternative	Result	Rationale
Natural recovery	Screened out	Contaminant levels, lack of ongoing sedimentation, desire to restore design depth
Thin-layer capping (enhanced natural recovery)	Screened out	Contaminant levels, conflict with vessel use
Engineered cap (chemical isolation)	Screened out	Conflict with vessel use and existing draft requirements
In-situ treatment	Screened out	Relatively untested; not effective or cost-efficient for thin sediments over a large area; still need dispose of material, which could double the cost
Dredging (mechanical)	**Carried forward**	
Dredging (hydraulic)	Screened out	Lack of suitable slurry detention area, need for a water treatment system before returning process water

Furthermore, the following alternatives for disposal of dredged sediment have been screened:

Disposal Alternative	Result	Rationale
Open water	Screened out	Contaminant levels, sediment toxicity
Upland landfill	**Carried forward**	
CAD	**Carried forward**	
NCDF (off-site)	**Carried forward**	
NCDF (on-site)	Screened out	Insufficient space; conflicts with site usage
Treatment/reuse	Screened out	Lack of willing recipients

5.8 Compilation of Remedial Alternatives

The remediation and disposal methods that are carried forward to the detailed alternatives evaluation have been assembled into four general remedial alternatives, as follows:

Alternative No. 1 – **No Action** (included as a base-case for comparison purposes)

Alternative No. 2 – **Mechanical dredging with disposal at upland landfill**

Alternative No. 3 – **Mechanical dredging with disposal at off-site NCDF**

Alternative No. 4 – **Mechanical dredging with disposal at CAD**

The following section evaluates each of these alternatives in detail.

6 EVALUATION CRITERIA FOR REMEDIAL ALTERNATIVES

The remedial alternatives considered in this study were evaluated based on current, available information on the affected sediment in the Rhine Channel. The focus of the remedial alternatives comparison will be technical effectiveness, implementability, environmental effectiveness, permittability, and cost.

6.1 Technical Effectiveness

In general terms, technical effectiveness answers the question, "Will the project work?" For the remedial alternatives, the following technical effectiveness issues were considered:

- Short-term effectiveness in removing or isolating the affected sediment from the environment in order to meet cleanup criteria
- Long-term effectiveness of the alternative to reduce chemical contamination, meet cleanup criteria, or to confine affected sediment and prevent contaminant mobility
- Reliability and previously demonstrated success elsewhere

6.2 Implementability

Implementability answers the question, 'Can the project be constructed?" For each of the remedial alternatives, the following implementability issues were considered:

- Constructability
- Site construction constraints, including available area for sediment rehandling and offloading
- In-water construction constraints
- Availability of technology, facilities, equipment, and trained workforce

6.3 Environmental Impacts

Environmental impacts address the question, 'How does the project affect the environment?" Environmental issues that are considered in this report include:

- Water quality
- Sediment quality
- Short term construction impacts on the environment
- Effects on fish and existing habitat

6.4 Permittability and Institutional Impacts

This section asks the question, "What are the challenges to permitting this project?" and "What are the project's effects on institutional site use or classification?" Permittability issues considered in this study include:

- Permit acquisition
- Existing and planned site use and adjacent property use
- Potential conflicts with adjacent uses, including potential future conflicts
- Mitigation of existing habitat resources
- Consistency with environmental, land use, and aquatic use regulations
- Public acceptance or opposition

Permit acquisition issues are similar for each of the remedial alternatives discussed in this study. For each of the alternatives, the Corps would need to approve permits pursuant to CWA Section 404 and River and Harbors Act Section 10. Hydraulic Project Approval would be required by the U.S. Fish and Wildlife Service for capping and dredging. The RWQCB would review and approve the CWA Section 401 permit. The California Department of Fish and Game, National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service also would provide their review and approval.

Federally-defined U.S. Bulkhead Lines and Pierhead Lines at the Rhine Channel have been established by Congress. Any changes to these lines will require congressional approval, as well as approval from the Corps for the in-water activity. Where changes to the U.S. Bulkhead Line are contemplated (as for relocation of existing bulkheads), the issue would be addressed concurrently with the Corps' Section 10/404 permitting, by a separate process.

An Environmental Impact Report (EIR) will be required by the California Environmental Quality Act (CEQA). The EIR will address impacts of the preferred alternative to the environment and will be prepared separate from this evaluation, although this report will provide technical information to support the EIR.

6.5 Cost

For each of the remedial alternatives, conceptual level costs were prepared for comparison. These estimates used consistent unit costs and methodology so that the remedial alternatives could be meaningfully compared relative to each other. The preliminary cost estimates reflect construction related costs (e.g., dredging, transportation, capping, disposal costs, and other capital costs) and also include costs for construction management, monitoring, permitting, and a contingency allotment.

6.5.1 General Assumptions

The following assumptions were used in developing the cost estimates for each of the remedial alternatives:

- Costs are based on a conceptual dredge plan involving the entire Rhine Channel. The volume of sediment was calculated based on interpretation of the contamination neatline from the 16 sediment cores taken in November 2004 and February 2005, as discussed in Section 3.4. Dredging volumes are based on a conceptual dredge plan, and include a six-inch allowable overdredge depth (as is described in Section 3.5). The full extent of the affected sediment is uncertain and may differ from the assumed estimates used for this evaluation.
- The cost estimates for material disposal assume that the material is classified as non-hazardous waste. Based on previous investigations, some small, isolated areas may contain pockets of material that exceed the criteria. The costs for managing that material separately are considered in the contingency factor and are not expected to be significant.
- Cost estimates for the remedial alternatives were compiled using typical construction scenarios assumed for the existing conditions. It is possible for these assumed scenarios to change during design.
- A 35 percent contingency factor has been added to the overall construction costs to reflect the potential for variations that may occur during design, as well as the potential for unknown situations or conditions to occur during construction. This contingency factor will be reduced as design efforts progress.
- Potential economic impacts to Rhine Channel businesses, personal property, and marina operations are not considered.
- Incurred costs of vessel relocation and pier disassembly and reconstruction are dependent upon a number of site- and property-specific factors which at this point have not been defined. Therefore, these costs have not been included in the comparative cost estimates.

- Estimated construction costs for environmental protection (temporary silt curtains) and monitoring (water quality during construction) have been included.
- Habitat mitigation costs are not included. At this point it is not known whether any habitat mitigation costs will be incurred by the project.

6.5.2 Specific Assumptions

The following specific design parameters, unit cost for materials, and weight to volume conversions were utilized in developing conceptual level costs:

- The in-situ weight of sand is assumed to weigh 110 pounds per cubic foot (1.5 tons per cy)
- Rock materials (riprap and quarry spalls) are assumed to weigh 140 pounds per cubic foot (1.9 tons per cy)
- A 10 hour work day is assumed for 5 days per week.
- A 5 to 6 cy mechanical clamshell bucket and a production rate of 750 cy per day is assumed.

7 EVALUATION OF SELECTED REMEDIAL ALTERNATIVES

Each of the remedial alternatives represents one potential construction scenario, for which conceptual-level costs and time frames have been estimated. These scenarios and costs do not reflect a design-level evaluation, but are sufficient for a relative comparison of the various alternatives that have been carried forward. This section further discusses construction elements and schedules at the conceptual level as they relate to the evaluation criteria detailed in Section 6. When possible and suitable, options for variables relating to construction techniques and equipment within each alternative are also discussed.

7.1 Remedial Alternative No. 1 – No Action

The no action scenario assumes that no remedial activities occur within the Rhine Channel. However, because the Rhine Channel sediments are known to contain chemical concentrations above scientifically accepted biological screening values for chemicals which EPA has developed Bay-wide TMDLs, it could be inferred that selecting this alternative does not support the Bay-wide TMDL action plan currently in development by the State Water Resources Control Board. Nevertheless, the no action alternative is evaluated here to serve as a 'base case' against which the other remedial alternatives can be compared.

7.1.1 Description and Sequence

The no action alternative would require no design or construction activities.

7.1.2 Technical Effectiveness

The no action alternative will not be effective at removing, isolating, nor confining affected sediments, either in the short-term or the long-term.

7.1.3 Implementability

The no action alternative has no implementability issues; there are no technical or scheduling constraints on its application.

7.1.4 Environmental Impacts

The no action alternative will incur significant long-term impacts on the environment, given the known contaminated sediments (and hence, water quality impacts) will remain present within the Rhine Channel in perpetuity. Similarly, leaving these sediments in place can be expected to pose deleterious impacts to fish and existing habitat within the channel. Designated beneficial uses for the Bay cannot be met under the no action alternative, as supported by the detailed risk assessment summarized in Section 3.4.4 and contained in Appendix D.

7.1.5 Permittability and Institutional Impacts

From a construction standpoint, permittability for construction activities is not an issue for the no action alternative, since no design or construction is necessary. From a larger perspective, however, this alternative has significant hurdles to regulatory acceptance. Most importantly, the EPA- and Regional Board-mandate to comply with defined TMDLs would be violated by the no action alternative, potentially exposing the City of Newport Beach to further regulatory action. While there will be no adverse short-term effects on shipping and navigation in the channel, the presence of contaminated sediments within the channel could severely restrict future site developments or improvements (such as channel deepening). As such, the no action alternative is considered to rank poorly for permittability and institutional impacts.

7.1.6 Cost Estimate

From a design and construction standpoint, the no action alternative has no associated costs, since no design or construction is necessary. However, the alternative poses other, less well-defined costs, insofar as leaving impacted sediments in place will curtail future site development and land use, and may additionally expose the City to regulatory action. These costs cannot be quantified and tabulated at this time, but are expected to be sizable. Future waterfront development costs within the vicinity of Rhine Channel will be significantly higher as a result of increased sediment dredging, permitting, and disposal costs for removing the contaminated sediments on a project-by-project basis.

7.1.7 Summary of Advantages/Disadvantages

The no action alternative has numerous disadvantages that potentially render it infeasible.

7.2 Remedial Alternative No. 2 – Dredging with Disposal at Upland Landfill

Under this scenario, sediments in the Rhine Channel that have contaminant concentrations greater than the cleanup criteria would be mechanically dredged, placed on a haul barge, de-watered, transported to a landside staging site, offloaded, and transported to an approved off-site upland disposal facility by truck or rail.

7.2.1 Description and Sequence

Prior to construction, the following activities will need to occur:

- Obtain applicable permits (6 months or more). Any unanticipated permitting issues would increase the project cost and duration.
- Design dredge plan (6 to 12 months). Design could begin prior to obtaining permits and would be expected to be completed 2 months after all permits are obtained. Figure 7 shows typical cross-sections through the channel, and indicates the projected extents of impacted sediments to be dredged at two selected and representative locations.
- Bid process to secure contractor (2 to 4 months). This effort includes time to advertise, review bids, award, negotiate, and issue a notice to proceed.

The anticipated construction elements and sequence of construction activities are generally described below:

- Remove existing structures (1 month). All floating piers and some of the concrete piling would need to be removed prior to dredging. Additionally, moored vessels would require temporary relocation. This could potentially be done in stages as dredging progresses in the channel.
- Dredge contaminated sediments (6 to 8 months). As discussed in Section 3.4, approximately 110,000 cy of sediment will be dredged. Dredging would likely be accomplished using a mechanical bucket dredge with a 5 to 6 cy bucket, due to the relatively thin layer of sediment and the fact that the overall site is relatively confined. The estimated production rate with this bucket is estimated to be approximately 750 cy per day. The sediment would be placed in haul barges, towed to an offloading area and offloaded with a re-handling bucket. A re-handling facility would be constructed near the site to stockpile the sediment that may require dewatering or stabilization prior to transport from the site. In

order to keep pace with the daily dredging rate, at least 5,000 square feet of area would need to be available for stockpiling, assuming an average stockpiled thickness of 6 to 8 feet. Additional upland area would be needed for contractor staging, equipment storage, etc.

- Conduct confirmatory sampling. Sampling would be conducted after dredging to determine whether all impacted sediment has in fact been removed. Areas that are shown to have remaining levels of residual chemical exceedances may be dredged further, or covered by a thin layer of clean sand, depending on the degree of exceedance that is indicated.
- Repair or replace selected lengths of bulkhead (1 month). Dredging of affected sediment near the portions of bulkhead that currently appear to be failing or in poor condition, is assumed to require stabilization or replacement of the bulkhead. Bulkheads would be repaired by building a new wall located 1-2 feet outward from the existing structure (as opposed to complete removal of the old one). Two separate costs for this alternative have been developed: one assuming that the bulkheads are either repaired as part of this project (Alternative 2A), and another assuming that bulkhead repair/replacement is accomplished separately by the individual property owners (Alternative 2B). Estimated costs are tabulated separately for both options.
- Replace piling and floating piers (2 months). Replacing or rebuilding of the floating pier system can be done in stages as dredging is completed in a certain areas.
- Haul dredged sediment off site (3 months, concurrent with dredging). The sediment would be hauled to an approved off-site, upland landfill in Orange County. Transportation would most likely occur by truck, since there are few usable rail spurs in the vicinity of the site. Depending on the disposal facility selected, the sediment would need to be dewatered in order to pass the paint filter test, typically a requirement for disposal at local landfills. As one option, a 2 to 4 percent cement admixture could be mixed with the dredged sediment to dewater it. Mixing could take place either in the barge or in an established landside stockpiling area; the treated sediment would be allowed to cure overnight and could be hauled away the next day. Alternatively, hydrocyclones,

centrifuges, or filter presses could be used for mechanical sediment dewatering (depending on costs).

- Estimated duration of construction: approximately 1 year.

7.2.2 Technical Effectiveness

Dredging and off-site disposal is a proven and reliable method for remediating contaminated sediments for sites such as the Rhine Channel. Dredging sediment with off-site disposal will effectively meet the cleanup goals of this project since sediment with concentrations that exceed the cleanup levels will be removed from the site and placed in a Subtitle D landfill or other approved disposal facility. Silt curtains could be used to minimize or avoid any short-term water quality impacts and have been included in the cost estimate for this alternative. Other controls would also be put in place to prevent any spillage during offloading that could result in water quality impacts.

Disposal at a permitted upland facility is technically effective since local permitted landfills are designed to accommodate the material and to properly isolate it from the environment. Controls can be instituted during transportation (likely via truck) to ensure that no material is spilled or lost.

7.2.3 Implementability

This alternative can be technically implemented using local contractors. Based on the core samples taken in November 2004 (summarized in Table 9), contamination is assumed to extend to depths of as much as 5.5 feet below the mudline. This sediment thickness can be readily removed with mechanical dredging equipment.

Dredging operations along bulkheads will reduce the overall stability of the bulkheads and, in areas where the bulkhead is in poor condition, could cause bulkhead failure. Mitigating measures will need to be developed that either repair or replace the damaged bulkhead. Possible options include:

- Leave the wall as-is and dredge sediment from in front of wall. This approach would require confirming that the wall was designed to support the required dredge elevation at the toe of the structure.

- Potentially upgrading or retrofitting existing bulkheads and replacing those that are currently in poor condition.
- Leaving a certain percentage of sediments in place to support the current bulkhead. Sediments that are left behind would potentially need to be capped; this could be confirmed through additional sampling.
- Constructing a rock 'buttress' along the new exposed toe of the bulkhead after the sediment is dredged. This would require dredging in limited (50-foot) sections along the wall, and putting down a wedge of rock rip-rap before dredging adjacent sections, to avoid leaving too much length of wall unsupported at any time.

For the purposes of the cost evaluations presented in this report, the final option (dredging and then placing a rock buttress) is assumed, since it is reasonably cost-effective and accomplishes full removal of the contaminated sediments.

Disposal at an upland landfill facility appears to be implementable, since chemical concentrations in the sediment do not exceed California hazardous waste criteria. The sediment could be disposed either as waste material (subject to a tipping fee of approximately $27 per ton), or if certain physical and chemical requirements are met, as ADC, which entails only a nominal tipping fee. Disposal of the waste as ADC would be subject to landfill operating capacity and usage rates for ADC, and would require demonstration that the sediment has sufficient moisture content, grain size, and chemical properties to meet acceptance requirements.

As stated in Section 3.1, some localized areas may contain metals concentrations above California Hazardous Waste threshold levels. These areas would need to be addressed on a case-by-case basis. Costs for addressing these areas will be further refined during the engineering design process, and for the time being are accounted for in the 35% contingency factor that has been applied to the cost estimate.

An upland area would need to be used as an offloading and re-handling site, preferably in the near vicinity of the project area. There appear to be limited upland areas within a 5-mile radius of the site of sufficient size to handle the amount of offloaded material and traffic pattern of the trucks. Two potential off-loading areas include the turning basin near the Cannery or an undeveloped area near the Pacific Coast Highway bridge over the Bay. A detailed coordination and logistics plan between dredging and offloading activities would be required. It is possible that these operations would need to occur on different shifts if dredging and backfilling operations are occurring near the offloading area. Given a 750 cy per day dredging rate, approximately 75 truck loads per day (or 38 truck and trailer loads) would be needed to transport the dredged sediment to a landfill.

The presence of the floating docks and supporting piles will interfere with dredging activities in the channel. These docks will require removal and replacement during construction.

Water depth and tide cycles in the channel will have an impact on daily operations. Derrick and haul barge size will be limited by the available draft in the channel at different tide cycles.

7.2.4 Environmental Impacts

This alternative impacts the entire Rhine Channel site. Dredging will remove the contaminated sediments and expose the underlying native sediments expected to relatively free of chemical impacts (subject to post-dredge confirmatory sampling) so there would be minimal long-term impacts. Dredging activities, however, will eliminate all existing benthic communities and vegetation, but these communities would likely be restored in approximately 1 to 3 years.

Dredging will result in increased turbidity within the channel, resulting in a potential for water quality impact or impacts to avian species foraging. Silt curtains or similar technology could be used to limit suspended sediment migration outside of the construction zone. Operational controls or specialized equipment could also be used to limit the release of suspended sediments, if required. These construction management approaches are standard practices for remediation dredging projects.

Navigation in the channel will be negatively impacted during implementation of this alternative. Dredging can be scheduled in stages to reduce the impact of vessels moored in the channel and local marine service industries that rely on the channel for ingress/egress to their businesses.

Local upland traffic patterns will be affected as the offloading trucks make their runs to the landfill facility, and the truck traffic could present a potential environmental impact (due primarily to exhaust and the risk of spillage), although controls to protect against these impacts would be required and implemented.

No long-term impacts to groundwater or marine waters are expected, since all contaminated sediments would be removed from the site and all generated water would be contained and treated.

There should be no adverse long-term environmental effects from upland disposal, since the selected disposal facility will be one that is permitted and designed to accommodate the waste sediment.

7.2.5 Permittability and Institutional Impacts

This alternative is not expected to have any unusual permitting or mitigation issues. Dredging projects have been permitted in this area in the past. Disposal will be conducted only at disposal facilities that are specifically permitted to accept sediment waste with site environmental components. Removing all contaminated sediments from the site should not negatively impact the adjacent uses or future uses of the channel. A future navigational benefit of this alternative will be a deeper channel. As such, this alternative is not expected to pose any hindrance to future site uses.

7.2.6 Cost Estimate

The estimated costs for this remedial alternative are displayed on Table 10. The total estimated cost, assuming that a full $27/ton tipping fee is paid for sediment disposal, is approximately $17 million. The majority of the costs associated with this option come from disposal of sediment as contaminated material waste within the landfill. If the material can be used as ADC, then considerable savings could be realized, with the total estimated cost dropping to about $11 million.

Other cost saving options (possibly on the order of $1 million) could potentially be attained for this alternative by using a mechanical dewatering technology (such as filter presses or hydrocyclones) instead of the chemical process (cement or lime stabilization) included in the initial estimate. The disadvantage of using a mechanical dewatering process is that it will require a water treatment system be implemented to manage the excess water. The cement stabilization process uses all of the in-situ water as part of the binding process, so no water discharge is required.

Less than 8 percent of the total length of the perimeter bulkhead appears to be in poor shape based on a visual site inspection (documented in Appendix C). The initial cost estimate includes the costs of full bulkhead replacement along this part of the channel length. If the failing bulkhead were left in place, or the replacement costs were assumed by the property owners, then another $1 million of the total costs could be saved. This assumption is considered in Alternative 2A.

All of the vessels moored in the marina would require temporary relocation as part of this alternative. These costs are not included in the total construction costs as they could be covered separately by the property owners.

7.2.7 Summary of Advantages/Disadvantages

This alternative is a common and effective remedial action that has a successful history in the region. Upon completion of the project, the contaminated sediments will be removed and transported to an appropriate disposal facility, so that the Rhine Channel meets cleanup criteria. Furthermore, the channel will be restored to its design depth for vessel navigation and provide a new substrate for the reestablishment of the benthic community (thus restoring one of the site's beneficial uses).

This alternative does have some disadvantages. The existing portions of the bulkhead that are in poor condition will need to be addressed, costing time and money. The local traffic both in the channel and surrounding upland area will be impacted during construction activities and the cost of rehandling material and upland disposal is very high. Also, an upland area will need to be temporarily set aside for staging, dewatering, and offloading; this may incur financial costs or may temporarily impact local site uses.

7.3 Remedial Alternative No. 3 – Dredging with Disposal at Off-Site NCDF

This alternative also involves dredging all chemically impacted sediments from the Rhine Channel, and in that respect the evaluation presented in the previous section is fully relevant to this alternative. The difference between Alternatives 2 and 3 is in the location of dredged sediment disposal and need to dewater the material prior to disposal. The following text presents an evaluation of the disposal (off-site NCDF) aspect of this alternative.

7.3.1 Description and Sequence

Sediment would be mechanically dredged, placed on barges, hauled and placed within a NCDF. An off-site NCDF would be required because, as was discussed in Section 5.5.3, the volume capacity achievable in potential on-site CDFs is insufficient to contain the estimated 110,000 cy of sediment. This alternative assumes that an off-site NCDF is already established or available within a 20 mile radius of the site to accept the dredged material by barge. Construction costs for an off-site NCDF are not included in this alternative.

The anticipated construction elements and sequence of construction activities include, but are not limited to, those described below:

- Permitting, design, bidding, and award (approximately 2 years assumed), as for Alternative 2.
- Remove existing structures (1 month). All floating piers and concrete piling would need to be removed prior to dredging. Additionally, moored vessels would require temporary relocation. This could potentially be done in stages as dredging progresses in the channel.
- Dredge contaminated sediments (6 to 8 months). As discussed in Section 3.4, approximately 110,000 cy of sediment will be dredged. Figure 6 shows typical cross-sections through the channel, and indicates the projected extents of impacted sediments to be dredged at two selected and representative locations.
- Dredging would likely be accomplished using a mechanical clamshell dredge with a 5 to 6 cy bucket with an estimated production rate of approximately 750 cy per day. The dredging methods proposed for this alternative are the same as for Alternative 2.

- Haul sediment by barge to an off-site NCDF (concurrent with dredging). The dredged sediment would be barged to an off-site NCDF and disposed of within the fill. Disposal within the NCDF fill would likely occur using a re-handling bucket to place the material over the sides of the rock dike.
- Repair or replace selected lengths of bulkhead (1 month). Dredging of affected sediment near the portions of bulkhead that currently appear to be failing or in poor condition is assumed to require stabilization or replacement of the bulkhead. Bulkheads would be repaired by building a new bulkhead wall located 1 to 2 feet outward from the existing one (as opposed to complete removal of the old one). As for Alternative 2, two separate costs for this alternative have been provided: either done as part of this project (Alternative 3A), or accomplished separately by the individual property owners (Alternative 3B).
- Replace piling and floating piers (2 months). Replacing or rebuilding of the floating pier system can be done in stages as dredging is completed in certain areas.
- Estimated duration of construction: approximately 1 year.

7.3.2 Technical Effectiveness

Dredging sediment and disposing it in an off-site NCDF would be effective in removing the sediment from the Rhine Channel and isolating the contaminants from the environment. Sediment that exceeds cleanup levels will be placed in the off-site NCDF. The chosen NCDF will be designed to isolate the material and prevent the contaminants from migrating to the surrounding surface water at concentrations greater than regulatory levels. This system is designed to be permanent and effective in the long term.

7.3.3 Implementability

This alternative can be technically implemented, but requires a suitable off-site NCDF within the region, such as those that have been constructed during the last decade for land reclamation purposes at the POLA and POLB. While port NCDF fill sites have been constructed on a somewhat consistent basis in recent years, changes in the level of scrutiny that they have received by local environmental activist groups has increased significantly. This has resulted in numerous lawsuits and delays to future development plans. Therefore, locating a suitable off-site NCDF disposal site may not be feasible in the next 5 – 10 years, making this alternative difficult to implement.

7.3.4 Environmental Impacts

Short-term impacts are the same as Alternative No. 2, but they are controllable through use of dredging Best Management Practices. No long-term impacts to groundwater or marine waters are expected since contaminated sediments would be confined within an off-site NCDF designed to chemically isolate the contained sediments from the environment.

No impact on local upland traffic is anticipated by this alternative, in the expectation that dredged sediment would be transported to the off-site NCDF via barge. This mode of transportation could present a potential environmental impact (due primarily to exhaust and the risk of spillage), although controls to protect against these impacts would be required and implemented.

7.3.5 Permittability and Institutional Impacts

This alternative can be easily permitted. Permitting issues associated with NCDF construction would be assumed to be addressed separately (by others) for the established off-site NCDF.

As was discussed for Alternative 2, dredging all contaminated sediments on the site would not be expected to impact the adjacent uses or future uses of the channel.

7.3.6 Cost Estimate

The estimated costs for this remedial alternative are displayed in Table 11. The total cost estimate amounts to approximately $7.5 million, reflecting a considerable savings over Alternative 2 (dredging with disposal at an upland landfill) since it assumes no tipping fee. The primary costs for disposal arise simply from transporting the material via barge to a hypothetical off-site NCDF and re-handling it into the NCDF. It is assumed that such a disposal scenario would not involve payment of a tipping fee, as has been the standard practice with local CDFs at the Ports of Los Angeles and Long Beach.

All of the vessels moored in the marina would require temporary relocation as part of this alternative. These costs are not included in the total construction costs as they could be covered separately by the property owners.

Less than 8 percent of the total length of the perimeter bulkhead appears to be in poor shape based on a visual site inspection (documented in Appendix C). This cost estimate includes bulkhead replacement. If the failing bulkhead were left in place or the replacement costs were assumed by the property owners, then approximately $1 million of the total costs could be saved. This option is considered Alternative 3A.

7.3.7 Summary of Advantages/Disadvantages

As mechanical dredging is the central focus of this remedial action, the advantages and disadvantages remain the same as in Alternative 2. The difference between these alternatives is the disposal option. A pre-established off-site NCDF would alleviate any permitting requirements related to the disposal site. Furthermore, assuming barge access to the off-site NCDF, there will be little impact on local upland traffic. Finding an acceptable NCDF site that is reachable by barge and that contains enough space for the volume of contaminated sediment remains the major challenge of this alternative. Current estimates from local Ports are for a net deficiency in available fill opportunities for the next 5 to 10 years. Further, even once a suitable NCDF is located and the Rhine Channel project permitted for construction, significant delays could occur as the selected NCDF could receive public opposition requiring additional environmental studies and agency review.

7.4 Remedial Alternative No. 4 – Dredging with Disposal in a CAD

Sediment would be mechanically dredged, placed on barges, and disposed of within a CAD. The CAD would be designed to contain the estimated 110,000 cy of sediment. Based on aerial photography and an initial site visit, adequate area to construct a CAD appears to exist in the general vicinity. The area located between Lido Island and the Balboa Peninsula just before the entrance to the Rhine Channel is the most probable location for the CAD (Figure 7). A CAD size of approximately 500 feet wide by 500 feet long and 20 feet deep (assuming 3:1 side slopes) would create sufficient disposal space for the contaminated sediments from the Rhine Channel. After the dredge sediment is placed in the CAD, it would be capped by approximately 5 feet of clean dredged sand, which could potentially be provided by a maintenance dredging project in the area. For this feasibility study, it is assumed that the clean sandy material excavated from the CAD site could be beneficially reused at a beach nourishment site located outside the harbor entrance.

7.4.1 Description and Sequence

The anticipated construction elements and sequence of construction activities include but are not limited to, those described below:

- Permitting, design, bidding, and award, potentially more involved for a CAD site than is expected for Alternatives 2 and 3 (duration estimated as approximately 2 to 4 years).
- Dredge CAD and dispose of sediment (6 months). The clean sediment, expected to be predominantly sand, will need to be barged to another location, or to an open-water disposal site. Some of the dredged CAD material could be sidecast and stockpiled on the channel bottom for later use as a final cap.
- Remove existing structures (1 month). All floating piers and concrete piling would need to be removed prior to dredging. Additionally, moored vessels from the CAD site would require temporarily relocation. This could potentially be done in stages as dredging progresses in the channel.
- Dredge contaminated sediments (6 to 8 months). As discussed in Section 3.4, approximately 110,000 cy of sediment will be dredged. Dredging would likely be accomplished using a mechanical clamshell dredge with a 5 to 6 cy bucket with an estimated production rate of approximately 750 cy per day. The dredging methods proposed for this alternative are similar to Alternative 2. The sediment would then be placed in haul barges that would be towed and disposed of in the CAD.
- Place a 5-foot-thick cap over the CAD site (2 to 4 weeks). Material that was excavated from the CAD and temporarily stockpiled below water could potentially be used for this purpose; we expect that the material dredged from the CAD would be sufficiently clean to be usable as part of the cap. Alternatively, materials dredged for channel maintenance elsewhere in the area could potentially be used for the 5-foot-thick cap.

- After the cap is placed, the underlying dredged sediments will undergo settlement, possibly on the order of a few to several feet. Once settlement has occurred, possibly after several months have passed, there will be a depression in the channel bottom. The channel bottom could be made flat by placing additional capping material. This is assumed to be needed 6 months after the 5-foot-thick cap has been constructed.
- Repair or replace failing bulkhead (1 month). Dredging of affected sediment near the failing portions of the bulkhead would require stabilization or replacement of the bulkhead as part of this alternative.
- Replace piling and floating piers (2 months). Replacing or rebuilding of the floating pier system can be done in stages as dredging is completed in a certain areas.
- Duration of Construction: 2 to 3 years (not including possible 2 to 4 year duration for permitting and design)

7.4.2 Technical Effectiveness

Dredging sediment and disposing in an on-site CAD would be effective in removing the sediment from the channel and isolating the contaminants from the environment as sediment that exceeds cleanup levels will be placed in the CAD. Provided there is sufficient area to construct a CAD, this alternative is technically effective.

The use of CAD sites for disposing of contaminated dredge material has been proven effective and reliable at other locations throughout the country. A local example using this technology was recently successfully constructed in the Long Beach inner harbor using contaminated sediments from the mouth of the Los Angeles River Estuary (USACE 2002). Intensive monitoring of that site by the Corps and the Los Angeles Contaminated Sediments Task Force for the past three years has shown effective isolation of the contaminants, no erosion of the cap surface, and rapid recolonization of the cap surface by benthic organisms. If constructed for the Rhine Channel, long-term monitoring of the CAD site would also be required.

7.4.3 Implementability

This alternative can be technically implemented but would require more dredging in order to construct the CAD. Additionally, clean native materials that are dredged from the CAD site would require placement off-site. A possible option for disposal of the clean native material, expected to be primarily sands, is alongside nearby beaches for sand renourishment projects being accomplished by the City or by other parties. This disposal option has been assumed for the purposes of the cost estimate because such projects have been undertaken on numerous occasions in the region. Barge, truck, rail and open-water disposal are also alternative transportation and disposal scenarios for the clean material, although they would be more costly. .

Dredging operations near areas where the bulkhead is in poor condition could cause bulkhead failure. Mitigating measures will need to be developed that either repair or replace the damaged bulkhead.

Currently, the area just outside of the Rhine Channel is used for offshore moorage. These vessels will need to be temporarily relocated and any moorage structures (anchor balls, piles, etc.) would require removal during construction.

7.4.4 Environmental Impacts

Dredging under this alternative will have the same impacts on the Rhine Channel as were described under Alternatives 2 and 3. There will be additional impacts, however, at the area designated for construction of the CAD. Studies conducted by the USACE (2002) and the Los Angeles CSTF have shown that the use of a CAD facility can be environmentally effective in the long-term, if properly constructed. In addition to the potential benthic impacts associated with the Rhine Channel dredging effort, benthic impacts may also occur during CAD site construction.

If the clean material dredged from the CAD site cannot be transported by barge, an offloading site will need to be constructed, which could impact upland traffic patterns. This could pose a significant increase to overall costs.

7.4.5 Permittability and Institutional Impacts

This alternative can potentially be permitted, although there are significant permitting issues associated with development and construction of a CAD site and disposal of chemically impacted sediments into the CAD. While this method of sediment disposal is quite common in other regions of the United States, it is still new in the Los Angeles Region and may not be found acceptable by the public and local environmental activist groups.

Dredging all contaminated sediments of the site should not impact the adjacent or future uses of the channel, but will limit future uses of the CAD area.

7.4.6 Cost Estimate

The estimated costs for this remedial alternative are displayed in Table 12. The total cost estimate for this alternative is approximately $12.6 million. Like Alternative 3, this disposal alternative does not involve tipping fees, either for the contaminated Rhine Channel sediment (which is placed directly into the CAD) or for the material excavated to create the CAD (which is assumed to go to a local beach renourishment project). Altogether the primary costs for sediment disposal would arise from excavating the CAD. In the absence of a suitable and reasonably local beach renourishment project, total costs for this alternative could increase significantly.

All of the vessels moored along the Rhine Channel would require temporary relocation as part of this alternative. These costs are not included in the total construction costs as they could be covered separately by the property owners.

Less than 8 percent of the total length of the perimeter bulkhead appears to be in poor shape based on visual observation (documented in Appendix C). This cost estimate includes bulkhead replacement. If the failing bulkhead were left in place or if the replacement costs were assumed by the property owners, then approximately $1 million of the total costs could be saved. This option is considered Alternative 4A.

7.4.7 Summary of Advantages/Disadvantages

As mechanical dredging is the central focus of this remedial action, the advantages and disadvantages related to the dredging portion of this alternative remain the same as in alternative 2. The difference between these alternatives is the disposal option. An on-site CAD requires more permitting than upland disposal but is potentially less expensive because the contaminated sediments are disposed of on-site, without a tipping fee. The clean material that is dredged from the CAD location will require disposal, which could potentially be done at a local beach for sand renourishment. This material can be disposed of by barge, by trucks, or in open-water disposal sites. These options each have permitting and cost issues. Finally, this alternative may restrict future use of the CAD site as the buried contaminated sediments must remain undisturbed. By incorporating a 5- foot-thick cap layer over the CAD, it is likely that the area will still be usable for temporary moorage, as it is now.

8 COMPARISON OF ALTERNATIVES

The remedial alternatives were evaluated to compare the relative performance of each in relation to the evaluation criteria. Qualitative rankings (poor, fair, and good) were assigned for each evaluation criteria. This ranking should be viewed as a preliminary indication of the most feasible alternative, because the rankings do not quantify the importance of each criteria relative to one another. Table 13 summarizes the comparison.

9 CONCLUSIONS AND RECOMMENDATIONS

The sampling and analysis described in this report indicate that sediments in the Rhine Channel above the native material are chemically impacted down to the interface between native and recent sediments. The thickness of this contaminated sediment layer ranges from 2 to 6 feet, resulting in a contaminated neatline volume on the order of 68,000 cy. Adding for inconsistencies in the depth of contamination between sampling stations, and for a 6 inch overdredge allowance, yields a total estimated volume of material for removal of 110,000 cy.

The screening of remedial alternatives presented in this report resulted in the elimination of engineered capping and other in-place measures from contention as stand-alone remedial alternatives (some of these may be suitable when combined with others). The most likely remedial alternatives involve mechanically dredging the sediment and disposing of it off-site. The most likely disposal options being at an upland landfill (Alternative 2), in an off-site NCDF constructed by others (Alternative 3), or in a CAD excavated near the mouth of the Rhine Channel (Alternative 4).

While all of these disposal alternatives are feasible, the NCDF option (Alternative 3) is contingent on development of such a facility by others (such as POLA or POLB), which at this time is unknown. The acceptability of disposal at an upland landfill (Alternative 2) is dependent on landfill acceptance of the waste and disposal at an on-site CAD facility (Alternative 4) would be subject to agency approval.

A cost comparison of these alternatives indicates that the mode of disposal can have a profound impact on costs. Disposal at an upland landfill is by far the most expensive option if full tipping fees for waste need to be paid. On the other hand, if the sediment were accepted for disposal as ADC, then the costs become similar to those for the NCDF and CAD disposal options.

Alternative 2 with ADC, if verified with local landfills, is the preferred alternative for the project, and it is recommended that this scenario, potentially with additional testing performed, be pursued further with local landfill representatives and regulatory agencies.

Disposal at a NCDF facility is fully dependent on decisions and actions by others, since it is reliant on a NCDF with sufficient capacity being constructed by another party; and (as discussed previously) constructing an on-site NCDF is prohibitive both from the standpoint of costs and of permitting. The largely hypothetical nature of the off-site NCDF alternative makes it, at this point, poorly suited as a recommended alternative. Should an appropriate site become available, then it would become the preferred alternative.

The option of disposal of dredged sediment in a constructed CAD is feasible, both from a technical and an environmental standpoint. However, while the CAD option is considered to be fully protective as an engineered disposal alternative based on results from other sites locally and nationally, it would potentially meet with resistance from local public environmental groups. Furthermore, excavating the CAD would require some up-front expenditure of capital, but beyond that the tipping costs could potentially be negligible if the excavated material could be hauled to a local beach renourishment project. Still, owing to the potential cost-effectiveness of this approach, this alternative is recommended as the secondary preferred alternative in the event that disposal of sediment as ADC at an upland landfill is not possible.

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TABLES

Table 1
Target Sediment Cleanup Values

Constituent of Concern	Newport Bay Sediment TMDL
Chlordane	2.26 µg/kg
Chromium	52 mg/kg
Copper	18.7 mg/kg
Dieldrin	0.72 µg/kg
Lead	30.2 mg/kg
Mercury	0.13 mg/kg
Zinc	124 mg/kg
Total DDT	3.89 µg/kg
Total PCBs	21.5 µg/kg

Table 2
List of Screening Criteria

Constituent of Concern	Newport Bay Sediment TMDL	ER-L	ER-M
Metals (mg/kg)			
Arsenic		8.2	70
Cadmium	0.67*	1.2	9.6
Chromium	52	81	371
Copper	18.7	34	270
Lead	30.2	46.7	218
Mercury	0.13	0.15	0.71
Nickel		20.9	51.6
Silver		1	3.7
Zinc	124	150	410
Organotins (µg/kg)			
Tributyltin		55.8	
SVOCs (µg/kg)			
Total PAHs		4,022	44,792
Pesticides (µg/kg)			
Chlordane	2.26		
Dieldrin	0.72		
Total DDT	3.89	1.58	46.1
PCBs (µg/kg)			
Total PCBs	21.5	22.7	180

* Cadmium TMDL technically applies to Upper Newport Bay - provided here for reference purposes only.

Table 3
Draft Results of Analytical Testing

Location ID				RS04-01	RS04-01	RS04-01	RS04-01	RS04-01	RS04-01	RS04-02	RS04-02	RS04-02	RS04-02	RS04-02	RS04-03	RS04-03	RS04-03	RS04-03	RS04-03
Sample ID			Newport	RC-1	RS04-01-0-60	RS04-01-60-120	RS04-01-120-140	RS04-01-140-150	RS04-01-150-200	RC-2	RS04-02-0-30	RS04-02-30-45	RS04-02-45-59	RS04-02-65-72	RC-3	RS04-03-0-30	RS04-03-30-38	RS04-03-38-68	RS04-03-68-86
Sample Date			Bay	SCCWRP '02	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	SCCWRP '02	11/10/2004	11/10/2004	11/10/2004	11/10/2004	SCCWRP '02	11/10/2004	11/10/2004	11/10/2004	11/10/2004
Depth Interval	ERL	ERM	TMDL	0-10 cm	0-60 cm	60-120 cm	120-140 cm	140-150 cm	150-200 cm	0-10 cm	0-30 cm	30-45 cm	45-59 cm	65-72 cm	0-10 cm	0-30 cm	30-38 cm	38-68 cm	68-86 cm
Conventionals (%)																			
Total Solids					39.60	47.70	57.30	66.20	75.50		59	59.10	54.30	78.10		79.90	55.20	64.10	73.30
Total Organic Carbon				1.49	2.64	2.44	1.46	0.45	0.23	2.53	1.85	2.21	2.99	0.04	1.76	1.29	1.63	1.19	0.43
Grain Size (%)																			
Gravel					0	0	0	0	0		0	0	0	0		0	0	0	0
Sand					5.77	15.56	8.18	63.65	60.40		30.57	25.33	3.72	95.98		26.25	17.79	16.67	58.39
Silt					72.87	65.52	66.53	26.90	29.51		53.41	56.55	69.31	4.02		54.84	63.91	58.98	31.27
Clay					21.37	18.92	25.30	9.46	10.09		16.02	18.12	26.97	0		18.91	18.30	24.35	10.33
Fines				81.6	94.23	84.44	91.82	36.35	39.60	71	69.43	74.67	96.28	4.02	71.8	73.75	82.21	83.33	41.61
Metals (mg/kg)																			
Aluminum					E	E	E	E	5330		E	E	E	6290		E	E	E	E
Arsenic	8.2	70		12	20.30	24.90	11.90	5.49	2.74	12.7	13.20	12.20	17.10	2.62	18.5	12.40	16.10	9.47	5.52
Cadmium	1.2	9.6	0.67*	0.61	2.07	2.53	1.36	0.37	0.11	0.84	1.04	1.64	1.37	0.08	1	0.90	1.64	1.01	0.34
Chromium	81	371	52	30	68.60	58.30	41.70	14.30	7.19	41	37.30	45.30	59.30	9.25	53.4	27.90	49	43.20	26.50
Copper	34	270	18.7	397	626	550	161	70.30	10.10	844	339	184	175	6.25	957	274	292	89.90	32
Iron					50800	54500	38900	13700	7770		29000	39600	64700	9870		22800	62200	39500	24800
Lead	46.7	218	30.2	72	186	185	99.70	25.50	7.88	105	122	117	5000	17.10	136	77.70	121	67.10	28.10
Mercury	0.15	0.71	0.13	8.2	3.66	5.29	2.30	1.39	0.23	8.9	2.43	2.38	1.31	0.23	12.8	2.29	2.02	1.10	0.29
Nickel	20.9	51.6		11.8	27.40	25.40	19.60	6.40	3.34	16.4	15.20	19.50	29.20	4.22	21.3	11.90	23	19.90	12.10
Selenium					2.01	1.43	1.09	0.36	0.29		1.35	0.99	1.18	0.24		0.74	0.90	0.93	0.46
Silver	1	3.7		0.43	0.45	0.44	0.16	0.04	0.02	0.24	0.18	0.20	0.43	0.05	0.23	0.13	0.20	0.17	0.06
Zinc	150	410	124	237	374	533	225	73.90	22.50	290	297	285	394	21.20	403	231	255	165	70.90
Organotins (µg/kg)																			
Monobutyltin					3 U	3 U	3 U	3 U	3 U		3 U	3 U	3 U	3 U		3 U	3 U	3 U	3 U
Dibutyltin					75	3 U	3 U	3 U	3 U		76	30.70	3 U	3 U		19	3 U	3 U	3 U
Tributyltin	55.8**				162	193	3 U	3 U	3 U		231	90.10	3 U	3 U		92.30	10.20	3 U	3 U
Tetrabutyltin					3 U	3 U	3 U	3 U	3 U		17	3 U	3 U	3 U		3 U	3 U	3 U	3 U
SVOCs (µg/kg)																			
Total PAHs (MTCA)	4022	44792		1340	880.50	7143.50	999.80	461.40	56.30	2200	5117.10	4162	1724.20	0	1530	18597.20	61954.40	466.80	128.50
Pesticides (µg/kg)																			
Total DDT (U=0)	1.58	46.1	3.89	30	0	193	0	0	0	56.5	36.80	0	0	0	46.1	0	0	0	0
PCBs (µg/kg)																			
Aroclor 1016					20 U	20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U
Aroclor 1221					20 U	20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U
Aroclor 1232					20 U	20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U
Aroclor 1242					20 U	349	20 U	20 U	20 U		20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U
Aroclor 1248					20 U	20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U
Aroclor 1254					64.50	252	20 U	20 U	20 U		88.80	20 U	20 U	20 U		76.70	20 U	20 U	20 U
Aroclor 1260					20 U	20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U		20 U	20 U	20 U	20 U
PCB Congeners (µg/kg)																			
Total PCBs (Congeners)	22.7	180	21.5	116	51.60	364	0	0	0	376	75.20	0	0	0	364	122	0	0	0

* Cadmium TMDL technically applies to Upper Newport Bay,
provided here for reference purposes only
Newport Bay TMDLs = Threshold Effect Levels (TELs)
= Exceeds the Newport Bay TMDL, but not the ER-L or ER-M
= Exceeds the TMDL (when applicable) and ER-L, but not the ER-M
= Exceeds the TMDL (when applicable), ER-L and the ER-M

** TBT Criteria = NOAA (Meador et al. 2002)
average TOC = 0.93%
criteria = 6000 ng/g OC
= 6000*0.0093
= 55.8 ng/g

Table 3
Draft Results of Analytical Testing

Location ID Sample ID Sample Date Depth Interval	ERL	ERM	Newport Bay TMDL	RS04-04 RC-4 SCCWRP '02 0-10 cm	RS04-04 RS04-04-0-25 11/10/2004 0-25 cm	RS04-04 RS04-04-25-50 11/10/2004 25-50 cm	RS04-04 RS04-04-50-99 11/10/2004 50-99 cm	RS04-05 RC-5 SCCWRP '02 0-10 cm	RS04-05 RS04-05-0-60 11/10/2004 0-60 cm	RS04-05 RS04-05-60-134 11/10/2004 60-134 cm	RS04-06 RC-6 SCCWRP '02 0-10 cm	RS04-06 RS04-06-0-40 11/10/2004 0-40 cm	RS04-06 RS04-06-40-120 11/10/2004 40-120 cm	RS04-06 RS04-06-120-200 11/10/2004 120-200 cm	RS04-07 RC-7 SCCWRP '02 0-10 cm	RS04-07 RS04-07-0-60 11/10/2004 0-60 cm	RS04-07 RS04-07-60-171 11/10/2004 60-171 cm	RS04-08 RC-8 SCCWRP '02 0-10 cm	RS04-08 RS04-08-0-30 11/10/2004 0-30 cm	RS04-08 RS04-08-30-90 11/10/2004 30-90 cm
Conventionals (%)																				
Total Solids					52.70	62.60	68.40		57.30	71.70		51.60	66.80	55.90		51.60	77.60		53.80	71.80
Total Organic Carbon				3.23	1.8	1.19	0.44	1.41	1.86	0.44	1.14	1.4	0.59	0.19	1.7	1.26	0.34	1.36	1.02	0.48
Grain Size (%)																				
Gravel					0	0	0		0	0		0	--	0		0	0		0	0
Sand					24.07	19.97	56.05		29.23	50.91		17.52	--	59.55		10.97	43.54		14.31	41.38
Silt					58.61	59.05	31.97		51.78	35.92		61.17	--	31.29		65.92	42.65		64.62	45.05
Clay					17.32	20.98	11.97		19.01	13.17		21.31	--	9.16		23.11	13.81		21.07	13.57
Fines				78.1	75.93	80.03	43.95	87.3	70.80	49.09	75.1	82.48	--	40.45	90.6	89.03	56.46	93	85.69	58.62
Metals (mg/kg)																				
Aluminum					E	E	E		E	E		E	E	9220		E	E		E	E
Arsenic	8.2	70		19.6	16.60	13.90	5.19	17	13.80	4.18	13.7	15.70	6.60	3.46	16.6	15.40	3.40	14.2	12.20	5.31
Cadmium	1.2	9.6	0.67*	2.13	1.02	1.21	0.46	0.94	1.59	0.20	0.88	1.08	0.50	0.16	0.95	1.06	0.13	0.73	0.70	0.24
Chromium	81	371	52	75.9	50.60	37.60	20.50	64.4	49.10	21.60	55.3	49.10	21.40	11.40	73.4	48.60	14.30	68.7	35.50	23.30
Copper	34	270	18.7	899	635	221	47.60	654	211	22.10	605	392	66.20	14.20	726	366	9.91	677	188	19.70
Iron					36200	31200	19000		39500	18100		36700	19700	10800		37300	13900		30100	22000
Lead	46.7	218	30.2	168	108	92	31.70	128	122	12.10	117	101	34.50	12.50	126	117	5.05	127	82.80	12.70
Mercury	0.15	0.71	0.13	14.3	3.68	2.82	0.94	11.1	2.98	0.25	8	3.18	1.20	0.45	9.2	3.63	0.15	8.7	2.87	0.19
Nickel	20.9	51.6		28.9	19.90	16	9.40	25.7	21	9.94	22.6	20.50	10.30	4.99	29.1	20.20	7.22	27.4	15.80	10.90
Selenium					1.33	0.85	0.39		1.05	0.40		1.47	0.64	0.33		1.70	0.34		1.07	0.36
Silver	1	3.7		0.25	0.37	0.61	0.08	0.21	0.20	0.05	0.18	0.31	0.08	0.04	0.21	0.35	0.02	0.19	0.15	0.05
Zinc	150	410	124	534	294	223	83.20	397	280	44.50	397	286	107	34.20	454	267	29.30	372	188	50.40
Organotins (µg/kg)																				
Monobutyltin					3 U	3 U	3 U		3 U	3 U		3 U	3 U	3 U		3 U	3 U		3 U	3 U
Dibutyltin					466	3 U	3 U		3 U	3 U		25.50	3 U	3 U		20	3 U		10.90	3 U
Tributyltin	55.8**				2770	19.40	3 U		51.20	3 U		82.30	3 U	4		37.50	3 U		30.30	3 U
Tetrabutyltin					48.70	3 U	3 U		3 U	3 U		21.80	3 U	3 U		3 U	3 U		3 U	3 U
SVOCs (µg/kg)																				
Total PAHs (MTCA)	4022	44792		2831	5312.10	1796.70	253.70	1200	3300.80	285.30	2410	743.90	780.10	166.40	864	787.20	0	1180	460.80	271.10
Pesticides (µg/kg)																				
Total DDT (U=0)	1.58	46.1	3.89	53.1	32.40	0	0	47.4	0	0	45.1	0	0	0	77.7	0	0	61	0	0
PCBs (µg/kg)																				
Aroclor 1016					20 U	20 U	20 U		20 U	20 U		20 U	20 U	20 U		20 U	20 U		20 U	20 U
Aroclor 1221					20 U	20 U	20 U		20 U	20 U		20 U	20 U	20 U		20 U	20 U		20 U	20 U
Aroclor 1232					20 U	20 U	20 U		20 U	20 U		20 U	20 U	20 U		20 U	20 U		20 U	20 U
Aroclor 1242					20 U	20 U	20 U		20 U	20 U		20 U	20 U	20 U		20 U	20 U		20 U	20 U
Aroclor 1248					20 U	20 U	20 U		20 U	20 U		20 U	20 U	20 U		20 U	20 U		20 U	20 U
Aroclor 1254					96	20 U	20 U		20 U	20 U		77.10	20 U	20 U		43	20 U		20 U	20 U
Aroclor 1260					20 U	20 U	20 U		20 U	20 U		20 U	20 U	20 U		20 U	20 U		20 U	20 U
PCB Congeners (µg/kg)																				
Total PCBs (Congeners)	22.7	180	21.5	401	151.80	0	0	248	0	0	191	75.10	0	0	179	35.20	0	230	0	0

* Cadmium TMDL technically applies to Upper Newport Bay, provided here for reference purposes only

Newport Bay TMDLs = Threshold Effect Levels (TELs)

= Exceeds the Newport Bay TMDL, but not the ER-L or ER-M

= Exceeds the TMDL (when applicable) and ER-L, but not the ER-M

= Exceeds the TMDL (when applicable), ER-L and the ER-M

** TBT Criteria = NOAA (Meador et al. 2002)
average TOC = 0.93%
criteria = 6000 ng/g OC
= 6000*0.0093
= 55.8 ng/g

Table 3
Draft Results of Analytical Testing

Location ID Sample ID Sample Date Depth Interval	ERL	ERM	Newport Bay TMDL	RS04-09 RC-9 SCCWRP '02 0-10 cm	RS04-09 RS04-09-0-35 11/10/2004 0-35 cm	RS04-09 RS04-09-35-110 11/10/2004 35-110 cm	RS04-10 RC-10 SCCWRP '02 0-10 cm	RS04-10 RS04-10-0-55 11/10/2004 0-55 cm	RS04-10 RS04-10-55-83 11/10/2004 55-83 cm	RS04-11 RC-11 SCCWRP '02 0-10 cm	RS04-11 RS04-11-0-43 11/10/2004 0-43 cm	RS04-11 RS04-11-50-63 11/10/2004 50-63 cm	RS04-12 RC-12 SCCWRP '02 0-10 cm	RS04-12 RS04-12-0-45 11/11/2004 0-45 cm	RS04-12 RS04-12-66-99 11/11/2004 66-99 cm	RS04-13 RC-13 SCCWRP '02 0-10 cm	RS04-13 RS04-13-0-50 11/11/2004 0-50 cm	RS04-13 RS04-13-50-83 11/11/2004 50-83 cm
Conventionals (%)																		
Total Solids					60.10	83.20		69.10	71.90		54.80	76.50		68.90	86.30		49.70	71.30
Total Organic Carbon				1.33	0.74	0.09	1.74	0.34	0.13	0.98	0.6	0.06	1.02	0.5	0.02	1.5	1.11	0.48
Grain Size (%)																		
Gravel					0	0		0	0		--	0		0	8.99		0	0
Sand					13.19	70.36		11.20	77.86		--	74.70		38.27	100		3.92	22.83
Silt					62.08	22.56		65.69	16.92		--	18.36		44.76	0		72.82	55.13
Clay					24.73	7.08		23.10	5.22		--	6.95		16.97	0		23.26	22.04
Fines				95	86.81	29.64	91.8	88.80	22.14	93	--	25.30	91.5	61.73	0	94.3	96.08	77.17
Metals (mg/kg)																		
Aluminum					E	2690		E	6560		E	3660		E	2330		E	E
Arsenic	8.2	70		17.7	10.40	2.28	16.6	4.56	3.45	12.5	10.50	2.90	12.9	8.69	1.95	15.5	12.10	6.45
Cadmium	1.2	9.6	0.67*	0.98	0.62	0.04	0.88	0.21	0.09	0.71	0.60	0.06	0.66	0.39	0.03	1.03	0.82	0.26
Chromium	81	371	52	86.2	35	3.61	68.9	10.90	9.73	63.4	32.90	4.67	63.1	23.80	3.14	74.5	50.20	27.30
Copper	34	270	18.7	847	191	3.18	761	88.90	5.95	495	209	5.29	691	145	1.33	651	184	32.10
Iron					26200	4560		9230	10600		24600	5380		18700	3420		36600	23300
Lead	46.7	218	30.2	138	57.20	1.88	127	20.50	2.58	98	64.50	3.79	94	50	1.08	122	67.20	22.40
Mercury	0.15	0.71	0.13	10.2	1.74	0.11	11.7	1.12	0.12	6.9	1.75	0.35	7.2	1.77	0.07	9.1	2.76	0.44
Nickel	20.9	51.6		34.1	14.20	2.01	27.3	4.87	5.18	25.2	13.60	2.49	24.5	10.20	1.34	29.2	20.70	12.30
Selenium					0.79	0.18		0.29	0.22		0.86	0.25		0.58	0.15		1.07	0.34
Silver	1	3.7		0.17	0.12	0.05 U	0.2	0.05	0.02	0.14	0.14	0.03		0.06	0.05 U	0.18	0.28	0.14
Zinc	150	410	124	440	149	9.49	378	58.80	21.70	301	163	12.70	337	111	4.84	386	189	68.90
Organotins (µg/kg)																		
Monobutyltin					3 U	3 U		3 U	3 U		3 U	3 U		3 U	3 U		3 U	3 U
Dibutyltin					156	3 U		23.60	3 U		42	3 U		3 U	3 U		3 U	3 U
Tributyltin	55.8**				847	3 U		87.70	2.21		93.60	3 U		71.10	3 U		57.80	3 U
Tetrabutyltin					34.30	3 U		12.20	3 U		3 U	3 U		3 U	3 U		3 U	3 U
SVOCs (µg/kg)																		
Total PAHs (MTCA)	4022	44792		1160	587.10	13.70	969	1341	24.70	829	1526.20	33.60	778	582	0	1171	581.30	274.40
Pesticides (µg/kg)																		
Total DDT (U=0)	1.58	46.1	3.89	59.9	5.10	0	49.7	0	0	58.8	0	0	46.7	0	0	51.4	0	0
PCBs (µg/kg)																		
Aroclor 1016					20 U	20 U		20 U	20 U		20 U	20 U		20 U	20 U		20 U	20 U
Aroclor 1221					20 U	20 U		20 U	20 U		20 U	20 U		20 U	20 U		20 U	20 U
Aroclor 1232					20 U	20 U		20 U	20 U		20 U	20 U		20 U	20 U		20 U	20 U
Aroclor 1242					20 U	20 U		20 U	20 U		45.10	20 U		20 U	20 U		20 U	20 U
Aroclor 1248					20 U	20 U		20 U	20 U		20 U	20 U		20 U	20 U		20 U	20 U
Aroclor 1254					30.40	20 U		42.80	20 U		71.30	20 U		22.80	20 U		20 U	20 U
Aroclor 1260					20 U	20 U		20 U	20 U		20 U	20 U		20 U	20 U		20 U	20 U
PCB Congeners (µg/kg)																		
Total PCBs (Congeners)	22.7	180	21.5	237	37	0	146	49.40	0	207	116	0	184	47.60	0	199	0	0

* Cadmium TMDL technically applies to Upper Newport Bay,
provided here for reference purposes only

Newport Bay TMDLs = Threshold Effect Levels (TELs)

= Exceeds the Newport Bay TMDL, but not the ER-L or ER-M

= Exceeds the TMDL (when applicable) and ER-L, but not the ER-M

= Exceeds the TMDL (when applicable), ER-L and the ER-M

** TBT Criteria = NOAA (Meador et al. 2002)
average TOC = 0.93%
criteria = 6000 ng/g OC
= 6000*0.0093
= 55.8 ng/g

Table 3
Draft Results of Analytical Testing

Location ID			Newport	RS04-14	RS04-14	RS04-14	RS2-14	RS2-14	RS2-14	RS04-15	RS04-15	RS04-15	RS04-15	RS04-16	RS04-16	RS04-16	RS2-16	RS2-16	RS2-16
Sample ID			Bay	RC-14	RS04-14-0-40	RS04-14-40-59	RS2-14-0-47	RS2-14-70-86	RS2-14-104-118	RC-15	RS04-15-0-40	RS04-15-40-80	RS04-15-80-95	RS04-16-0-50	RS04-16-50-100	RS04-16-100-150	RS2-16-0-53	RS2-16-70-90	RS2-16-130-140
Sample Date				SCCWRP '02	11/11/2004	11/11/2004	2/9/2005	2/9/2005	2/9/2005	SCCWRP '02	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	2/9/2005	2/9/2005	2/9/2005
Depth Interval	ERL	ERM	TMDL	0-10 cm	0-40 cm	40-59 cm	0-47 cm	70-86 cm	104-118 cm	0-10 cm	0-40 cm	40-80 cm	80-95 cm	0-50 cm	50-100 cm	100-150 cm	0-53 cm	70-90 cm	130-140 cm
Conventionals (%)																			
Total Solids					61.10	69.40					58.20	62.10	79.10	57.90	51.90	69.70			
Total Organic Carbon				1.68	0.66	0.05				1.6	0.96	0.66	0.04	1.8	1.32	0.58			
Grain Size (%)																			
Gravel					0	0					0	0	0	0	0	0			
Sand					16.82	92.75					6.32	16.72	51.39	25.21	14.69	34.55			
Silt					61.51	6.35					69.65	60.57	36.30	58.75	61.63	46.79			
Clay					21.67	0.89					24.03	22.71	12.31	16.03	23.67	18.66			
Fines				93.1	83.18	7.25				92.2	93.68	83.28	48.61	74.79	85.31	65.45			
Metals (mg/kg)																			
Aluminum					E	E	36400	2790	1750		E	E	2330	E	E	E	36000	11000	4240
Arsenic	8.2	70		11.9	13.40	8.70	16.5	1.76	1.91	8.8	12.80	8.38	2.44	12.80	13.30	8.31	11.4	3.11	1.82
Cadmium	1.2	9.6	0.67*	0.71	0.56	0.41	0.63	0.05 U	0.05 U	0.63	0.57	0.44	0.03	0.93	1.75	0.72	1.11	0.076	0.05 U
Chromium	81	371	52	64.3	39.50	24.50	34.7	0.94	0.49	46.9	40.80	31.30	4.11	39.20	46.20	38.20	3.08	9.5	3.08
Copper	34	270	18.7	382	135	147	235	0.853	0.671	225	354	69.50	1.57	521	173	69.40	229	8.12	3.02
Iron					32500	18800	34200	3810	2890		29700	26700	3820	28000	37400	34600	36400	14000	6200
Lead	46.7	218	30.2	81	46.90	42.50	70.4	0.853	0.521	44	156	81.70	1.93	159	139	69.50	93	9.5	1.91
Mercury	0.15	0.71	0.13	6.7	1.95	2.14	10	0.007 E	0.064	2.4	2.07	0.70	0.08	2.42	2.80	0.73	4.81	0.132	0.063
Nickel	20.9	51.6		25.9	17.20	10.20	15.1	1.1	1.31	19.5	17.60	14.30	1.69	15.40	20.30	17.60	15	5.1	1.88
Selenium					0.71	0.48	0.09	0.318	0.82		0.86	0.59	0.25	0.95	0.85	0.65	1.1	0.521	0.433
Silver	1	3.7		0.22	0.12	0.10	0.105	0.05 U	0.05 U	0.35	0.19	0.07	0.05	0.22	0.26	0.19	0.104	0.05 U	0.05 U
Zinc	150	410	124	303	120	108	172	4.21	2.65	228	163	80.60	5.58	277	279	148	189	27	8.59
Organotins (µg/kg)																			
Monobutyltin					3 U	3 U					3 U	3 U	3 U	3 U	3 U	3 U			
Dibutyltin					3 U	3 U					13.50	3 U	3 U	429	18.40	3 U			
Tributyltin	55.8**				1.90	3.70					29.90	3 U	3 U	2870	40.90	3 U			
Tetrabutyltin					3 U	3 U					3 U	3 U	3 U	52.60	3 U	3 U			
SVOCs (µg/kg)																			
Total PAHs (MTCA)	4022	44792		1320	151.70	105.70				1380	199.60	118.10	0	5815.3	711.30	134.50			
Pesticides (µg/kg)																			
Total DDT (U=0)	1.58	46.1	3.89	97.9	0	0				42.3	10.80	0	0	68.10	0	0			
PCBs (µg/kg)																			
Aroclor 1016					20 U	20 U					20 U	20 U	20 U	20 U	20 U	20 U			
Aroclor 1221					20 U	20 U					20 U	20 U	20 U	20 U	20 U	20 U			
Aroclor 1232					20 U	20 U					20 U	20 U	20 U	20 U	20 U	20 U			
Aroclor 1242					20 U	20 U					20 U	20 U	20 U	20 U	20 U	20 U			
Aroclor 1248					20 U	20 U					20 U	20 U	20 U	20 U	20 U	20 U			
Aroclor 1254					20 U	20 U					20 U	20 U	20 U	244	20 U	20 U			
Aroclor 1260					20 U	20 U					20 U	20 U	20 U	20 U	20 U	20 U			
PCB Congeners (µg/kg)																			
Total PCBs (Congeners)	22.7	180	21.5	259	0	0				51	0	0	0	382	0	0			

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Newport Bay TMDLs = Threshold Effect Levels (TELs)

(yellow) = Exceeds the Newport Bay TMDL, but not the ER-L or ER-M

(orange) = Exceeds the TMDL (when applicable) and ER-L, but not the ER-M

(red) = Exceeds the TMDL (when applicable), ER-L and the ER-M

** TBT Criteria = NOAA (Meador et al. 2002)
average TOC = 0.93%
criteria = 6000 ng/g OC
= 6000*0.0093
= 55.8 ng/g

Table 4
Total Mercury (mg/Kg), Methyl Mercury (mg/Kg), and Percent Methyl Mercury Measured at Stations RS04 -01, 04, 14, and 16

Mercury (mg/Kg)	Depth	RS2-1	RS2-4	RS2-14	RS2-16	Depth Average	Overall Average
Total	0-2 cm	7.59	9.56	5.05	6.33	7.13	9.45
	20-22 cm			15.96	12.22	14.09	
Methyl	0-2 cm	0.0033	0.0034	0.0016	0.0020	0.003	0.002
	20-22 cm			0.0024	0.0023	0.002	
% Methyl	0-2 cm	0.043	0.035	0.032	0.032	0.036	0.029
	20-22 cm			0.01	0.02	0.017	

Table 5
Calculated ERM Quotients for Stations RS04-01 Through 16 - Rhine Channel, Newport Beach, California

Location ID	Station RS04-01					Station RS04-02				Station RS04-03				Station RS04-04			Station RS04-05	
Sample Date	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004
Depth Interval	0-60 cm	60-120 cm	120-140 cm	140-150 cm	150-200 cm	0-30 cm	30-45 cm	45-59 cm	65-72 cm	0-30 cm	30-38 cm	38-68 cm	68-86 cm	0-25 cm	25-50 cm	50-99 cm	0-60 cm	60-134 cm
Arsenic ERM quotient	0.3	0.4	0.2	0.1	0.0	0.2	0.2	0.2	0.0	0.2	0.2	0.1	0.1	0.2	0.2	0.1	0.2	0.1
Cadmium ERM quotient	0.2	0.3	0.1	0.0	0.0	0.1	0.2	0.1	0.0	0.1	0.2	0.1	0.0	0.1	0.1	0.0	0.2	0.0
Chromium ERM quotient	0.2	0.2	0.1	0.0	0.0	0.1	0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Copper ERM quotient	2.3	2.0	0.6	0.3	0.0	1.3	0.7	0.6	0.0	1.0	1.1	0.3	0.1	2.4	0.8	0.2	0.8	0.1
Lead ERM quotient	0.9	0.8	0.5	0.1	0.0	0.6	0.5	22.9	0.1	0.4	0.6	0.3	0.1	0.5	0.4	0.1	0.6	0.1
Mercury ERM quotient	5.2	7.5	3.2	2.0	0.3	3.4	3.4	1.8	0.3	3.2	2.8	1.5	0.4	5.2	4.0	1.3	4.2	0.4
Nickel ERM quotient	0.53	0.49	0.38	0.12	0.06	0.29	0.38	0.57	0.08	0.23	0.45	0.39	0.23	0.39	0.31	0.18	0.41	0.19
Silver ERM quotient	0.12	0.12	0.04	0.01	0.01	0.05	0.05	0.12	0.01	0.04	0.05	0.05	0.02	0.10	0.16	0.02	0.05	0.01
Zinc ERM quotient	0.9	1.3	0.5	0.2	0.1	0.7	0.7	1.0	0.1	0.6	0.6	0.4	0.2	0.7	0.5	0.2	0.7	0.1
Total PAHs ERM quotient	0.02	0.16	0.02	0.01	0.00	0.11	0.09	0.04	0.00	0.42	1.38	0.01	0.00	0.12	0.04	0.01	0.07	0.01
Total PCBs ERM quotient	0.29	2.02	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.84	0.00	0.00	0.00	0.00
Total DDT ERM quotient	0.0	4.2	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0
Mean ERM quotient	0.91	**1.62**	0.48	0.23	0.05	0.67	0.52	**2.30**	0.05	0.57	0.63	0.28	0.11	0.95	0.56	0.19	0.60	0.08

Location ID	Station RS04-06			Station RS04-07		Station RS04-08		Station RS04-09		Station RS04-10		Station RS04-11		Station RS04-12		Station RS04-13	
Sample Date	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/11/2004	11/11/2004	11/11/2004	11/11/2004
Depth Interval	0-40 cm	40-120 cm	120-200 cm	0-60 cm	60-171 cm	0-30 cm	30-90 cm	0-35 cm	35-110 cm	0-55 cm	55-83 cm	0-43 cm	50-63 cm	0-45 cm	66-99 cm	0-50 cm	50-83 cm
Arsenic ERM quotient	0.2	0.1	0.0	0.2	0.0	0.2	0.1	0.1	0.0	0.1	0.0	0.2	0.0	0.1	0.0	0.2	0.1
Cadmium ERM quotient	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Chromium ERM quotient	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.1
Copper ERM quotient	1.5	0.2	0.1	1.4	0.0	0.7	0.1	0.7	0.0	0.3	0.0	0.8	0.0	0.5	0.0	0.7	0.1
Lead ERM quotient	0.5	0.2	0.1	0.5	0.0	0.4	0.1	0.3	0.0	0.1	0.0	0.3	0.0	0.2	0.0	0.3	0.1
Mercury ERM quotient	4.5	1.7	0.6	5.1	0.2	4.0	0.3	2.5	0.2	1.6	0.2	2.5	0.5	2.5	0.1	3.9	0.6
Nickel ERM quotient	0.40	0.20	0.10	0.39	0.14	0.31	0.21	0.28	0.04	0.09	0.10	0.26	0.05	0.20	0.03	0.40	0.24
Silver ERM quotient	0.08	0.02	0.01	0.09	0.01	0.04	0.01	0.03	0.01	0.01	0.01	0.04	0.01	0.02	0.01	0.08	0.04
Zinc ERM quotient	0.7	0.3	0.1	0.7	0.1	0.5	0.1	0.4	0.0	0.1	0.1	0.4	0.0	0.3	0.0	0.5	0.2
Total PAHs ERM quotient	0.02	0.02	0.00	0.02	0.00	0.01	0.01	0.01	0.00	0.03	0.00	0.03	0.00	0.01	0.00	0.01	0.01
Total PCBs ERM quotient	0.42	0.00	0.00	0.20	0.00	0.00	0.00	0.21	0.00	0.27	0.00	0.64	0.00	0.26	0.00	0.00	0.00
Total DDT ERM quotient	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean ERM quotient	0.71	0.23	0.09	0.73	0.05	0.52	0.08	0.39	0.02	0.22	0.04	0.43	0.06	0.35	0.02	0.52	0.12

Location ID	Station RS04-14					Station RS04-15			Station RS04-16					
Sample Date	11/11/2004	11/11/2004	2/9/2005	2/9/2005	2/9/2005	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	11/10/2004	2/9/2005	2/9/2005	2/9/2005
Depth Interval	0-40 cm	40-59 cm	0-47 cm	70-86 cm	104-118 cm	0-40 cm	40-80 cm	80-95 cm	0-50 cm	50-100 cm	100-150 cm	0-53 cm	70-90 cm	130-140 cm
Arsenic ERM quotient	0.2	0.1	0.2	0.0	0.0	0.2	0.1	0.0	0.2	0.2	0.1	0.2	0.0	0.0
Cadmium ERM quotient	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.2	0.1	0.1	0.0	0.0
Chromium ERM quotient	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Copper ERM quotient	0.5	0.5	0.9	0.0	0.0	1.3	0.3	0.0	1.9	0.6	0.3	0.8	0.0	0.0
Lead ERM quotient	0.2	0.2	0.3	0.0	0.0	0.7	0.4	0.0	0.7	0.6	0.3	0.4	0.0	0.0
Mercury ERM quotient	2.7	3.0	14.1	0.0	0.1	2.9	1.0	0.1	3.4	3.9	1.0	6.8	0.2	0.1
Nickel ERM quotient	0.33	0.20	0.29	0.02	0.03	0.34	0.28	0.03	0.30	0.39	0.34	0.29	0.10	0.04
Silver ERM quotient	0.03	0.03	0.03	0.01	0.01	0.05	0.02	0.01	0.06	0.07	0.05	0.03	0.01	0.01
Zinc ERM quotient	0.3	0.3	0.4	0.0	0.0	0.4	0.2	0.0	0.7	0.7	0.4	0.5	0.1	0.0
Total PAHs ERM quotient	0.00	0.00				0.00	0.00	0.00	0.13	0.02	0.00			
Total PCBs ERM quotient	0.00	0.00				0.00	0.00	0.00	2.12	0.00	0.00			
Total DDT ERM quotient	0.0	0.0				0.2	0.0	0.0	1.5	0.0	0.0			
Mean ERM quotient	0.37	0.37	**1.82**	0.01	0.02	0.53	0.20	0.02	0.93	0.57	0.22	**1.01**	0.06	0.02

Table 6
Summary of Species Evaluated for Bioaccumulation Risk Assessment

Trophic Guild	Species	Environment	Reason for Selection
Fishes			
Planktivorous fish	California killifish (*Fundulus parvipinnis*)	Shallow, sheltered waters. High site fidelity	Prey item for piscivorous fish and birds. Feeds throughout the water column
Benthivorous fish	Arrow Goby (*Clevelandia ios*)	Shallow water, soft bottom substrate	Prey item for fish and birds. Consumes benthos. Burrows in sediments.
	Diamond Turbot *(Hypsopsetta guttulata)*	Shallow water, soft bottom substrate	Prey item for harbor seal. Consumes benthos
Piscivorous fish	California halibut (*Paralichthys californicus*)	Shallow and deep waters, soft bottom substrate	Prey item for harbor seal. Consumes fish
Birds			
Piscivorous birds	Brown pelican (*Pelecanus occidentalis*)	Open water/channel island rookeries	State and federally endangered species
	Double crested Cormorant *(Phalacrocorax auritus)*	Open water/rocky headlands and islands.	Common around wharfs and areas with little vegetation. Can have high site fidelity. Commonly used as environmental indicator species.
Mammals			
Piscivorous mammal	Harbor seal (*Phoca vitulina*)	Nearshore habitats.	Common pinniped. Consumes fish.

Table 7
Summary of Measured and Modeled Chemical Concentrations in Sediment, Porewater, and Surface Water

Chemical	Statistical Value	Sediment (ng/g dw)	Calculated (EqP) Porewater (ng/L)	Measured Water Concentrations (ng/L)
Copper	Min.	225,000	71,151	5,780
	Mean	654,000	206,813	11,560
	95% UCL	768,000	242,863	23,120
	Max.	957,000	302,630	34,680
Mercury	Min.	2,400	30	5
	Mean	9,000	113	10
	95% UCL	10,600	133	20
	Max.	14,300	180	30
Selenium	Min.	1,270	319	10
	Mean	2,360	593	20
	95% UCL	2,630	661	40
	Max.	3,120	784	60
DDE	Min.	30	0.612	0.336
	Mean	54.9	1.37	0.672
	95% UCL	63.7	1.58	1.34
	Max.	97.9	3.90	2.02
PCBs (Total)	Min.	51	1.66	0.146
	Mean	225.9	8.98	0.292
	95% UCL	279.1	11.1	0.584
	Max.	401	25.5	0.876

The EqP concentration is equivalent to a porewater measurement.
The measured concentrations for metals were based on the water column and the sediment-water interface concentration that were measured at the bend of Rhine Channel at Station NB3 (SCCWRP 2004a). The PCB and DDE concentrations applied in the model were those calculated by EqP; the values measured in Turning Basin water samples (SCCWRP 2004a) are included herein for reference. For the measured water concentrations, the base SWI value was multiplied by 2, 4, and 6 respectively to provide a conservative safety factor.
Highlighted values are those water concentrations used in the model.

Table 8
Summary of Toxicity Reference Values Exceedences at Modeled Concentrations for Bioaccumulative Contaminants of Concern and Receptors of Concern

Chemical	Arrow Goby	Killifish	Turbot	Halibut	Pelican	Cormorant	Seal
Copper	NOAEL @ mean; LOAEL @ UCL95, Surface water > AWQC	NOAEL @ mean; LOAEL @ UCL95, Surface water > AWQC	NOAEL @ mean; LOAEL @ UCL95, Surface water > AWQC	NOAEL @ mean; LOAEL @ UCL95, Surface water > AWQC			
Mercury	NOAEL @ mean; LOAEL @ UCL95, Surface water < AWQC, Measured tissue < TRV	NOAEL @ mean; LOAEL @ UCL95, Surface water < AWQC, Measured tissue < TRV	NOAEL @ mean; LOAEL @ UCL95, Surface water < AWQC, Measured tissue < TRV	NOAEL @ mean; LOAEL @ UCL95, Surface water < AWQC, Measured tissue < TRV		NOAEL @ max measured tissue; Measured tissue LOAEL HQ < 1	
Selenium							
DDE					NOAEL @ max; Egg NOAEL @ mean, Egg LOAEL @ max	NOAEL @ UCL95 Egg NOAEL @ min, Egg LOAEL @ UCL95	
PCBs		NOAEL @ max	NOAEL @ max	NOAEL @ max	Egg NOAEL and LOAEL @ mean	NOAEL @ Max Egg NOAEL and LOAEL @ mean	NOAEL @ mean

NOAEL – no observable adverse effect level
LOAEL – lowest observable adverse effect level
TRV – toxicity reference value
UCL 95 – 95 % upper confidence level of the mean sediment concentration
Mean – average sediment concentration
Max – maximum sediment concentration
AWQC – ambient water quality criteria

Table 9
Summary or Thickness and Volume of Impacted Sediment

Station	Area (sq.ft.)	Depth to Native (ft)	Volume (cy)	1 ft add'l volume	6 inches overdredge
RS-1	18457	5.5	3768	684	342
RS-2	20050	2.3	1725	743	371
RS-3	28487	2.7	2825	1055	528
RS-4	39718	2.0	2896	1471	736
RS-5	49422	2.4	4324	1830	915
RS-6	38487	4.7	6734	1425	713
RS-7	57601	2.4	5039	2133	1067
RS-8	49764	1.2	2177	1843	922
RS-9	30781	1.4	1571	1140	570
RS-10	64852	2.2	5201	2402	1201
RS-11	36253	1.7	2273	1343	671
RS-12	37516	2.6	3610	1389	695
RS-13	83501	2.0	6088	3093	1546
RS-14	86417	1.6	5040	3201	1600
RS-15	126599	3.1	14768	4689	2344
RS-16		3.9			
Totals			**68039**	**28441**	**14220**

Table 10
Estimated Cost - Alternative 2

ALTERNATIVE 2 - DREDGING WITH DISPOSAL AT LANDFILL

Cleanup to:
Remedial Activity: **Dredging (Mechanical)**
Disposal: **Upland Landfill**

Task	Unit	Unit Cost	Quantity	Total Cost
1. DIRECT CONSTRUCTION COSTS				
1.1 PRE-CONSTRUCTION / SITE PREPARATION				
a. Mobilization/Demobilization	LS	$100,000	1	$ 100,000
b. Prepare Upland Staging, Offloading, Dewatering Area	LS	$150,000	1	$ 150,000
c. Temporary relocation of marinas (incl. reinstallation)	LS	$0	1	$ -
1.2 DEMOLITION	LS	$100,000	1	$ 100,000
1.3 DREDGING (MECHANICAL)				
a. Debris Removal	LS	$100,000	1	$ 100,000
b. Dredging in main channel	CY	$10	82,500	$ 825,000
c. Dredging within marina/seawall areas	CY	$14	27,500	$ 385,000
d. Thin-layer capping of residuals	CY	$20	10,000	$ 200,000
e. Silt Curtain/Oil Boom/BMPs	LS	$100,000	1	$ 100,000
1.4 SEAWALLS & STRUCTURES				
a. Cap for replacement bulkhead (in front of old seawall)	LF	$350	400	$ 140,000
b. Purchase and Install sheetpile bulkhead	LF	$1,500	400	$ 600,000
c. Cap / Rock Buttress along Seawalls. Purchase and place.	TON	$30	5,400	$ 162,000
1.5 SEDIMENT TREATMENT AND DISPOSAL (LANDFILL)				
a. Dewatering (add 2% cement) and rehandling	CY	$8	110,000	$ 880,000
b. Transport to landfill	TON	$15	168,300	$ 2,524,500
c. Tipping Fee	TON	$27	168,300	$ 4,544,100
TOTAL DIRECT CONSTRUCTION COSTS				**$ 10,810,600**
2. INDIRECT CONSTRUCTION COSTS				
2.1 CONSTRUCTION MANAGEMENT AND SURVEYING	LS	$500,000	1	$ 500,000
2.2 WATER QUALITY MONITORING	week	$12,000	36	$ 432,000
2.3 CONFIRMATIONAL SEDIMENT SAMPLING	sample	$2,500	50	$ 125,000
TOTAL INDIRECT CONSTRUCTION COSTS				**$ 1,057,000**
SUBTOTAL CONSTRUCTION COSTS				**$ 11,867,600**
3. CONSTRUCTION CONTINGENCY	percent	35%	1	$ 4,153,660
TOTAL CONSTRUCTION COSTS				**$ 16,021,260**
4. NON-CONSTRUCTION COSTS				
4.1 SUPPLEMENTAL DESIGN SAMPLING	LS	$200,000	1	$ 200,000
4.2 ENGINEERING DESIGN AND PERMITTING SUPPORT	LS	$500,000	1	$ 500,000
4.3 ENVIRONMENTAL IMPACT REVIEW	LS	$100,000	1	$ 100,000
4.4 REGIONAL BOARD OVERSIGHT COST	YR	$50,000	2	$ 100,000
4.5 HABITAT EVALUATION (EFH) COSTS	LS	$40,000	1	$ 40,000
4.6 HABITAT MITIGATION	Acre	$100,000	TBD	$ -
GRAND TOTAL				**$ 16,961,260**

MODIFICATIONS TO TOTAL	
Alternative 2A - Total with no bulkhead replacement (1.4 a and b)	$ 15,862,260
Total with no tipping fee (1.5 c used as daily cover)	$ 10,726,725
Total with no tipping fee and no bulkhead replacement	$ 9,727,725
Total with mechanical dewatering instead of cement admixing	$ 16,118,760
Total with mechanical dewatering and no bulkhead replacement and no tipping fee.	$ 8,985,225

Table 11
Estimated Cost - Alternative 3

ALTERNATIVE 3 - DREDGING WITH DISPOSAL AT OFFSITE CDF

Cleanup to:
Remedial Activity: **Dredging (Mechanical)**
Disposal: **Offsite CDF**

Task	Unit	Unit Cost	Quantity	Total Cost
1. DIRECT CONSTRUCTION COSTS				
1.1 PRE-CONSTRUCTION / SITE PREPARATION				
a. Mobilization/Demobilization	LS	$100,000	1	$ 100,000
b. Prepare Upland Staging, Offloading, Dewatering Area	LS	$100,000	1	$ 100,000
c. Temporary relocation of marinas (incl. reinstallation)	LS	$0	1	$ -
1.2 DEMOLITION	LS	$100,000	1	$ 100,000
1.3 DREDGING (MECHANICAL)				
a. Debris Removal	LS	$100,000	1	$ 100,000
b. Dredging in main channel	CY	$10	82,500	$ 825,000
c. Dredging within marina/seawall areas	CY	$14	27,500	$ 385,000
d. Thin-layer capping of residuals	CY	$20	10,000	$ 200,000
e. Silt Curtain/Oil Boom/BMPs	LS	$100,000	1	$ 100,000
1.4 SEAWALLS & STRUCTURES				
a. Cap for replacement bulkhead (in front of old seawall)	LF	$350	400	$ 140,000
b. Purchase and Install sheetpile bulkhead	LF	$1,500	400	$ 600,000
c. Cap / Rock Buttress along Seawalls not in CDF. Purchase and place.	TON	$30	5,400	$ 162,000
1.5 OFF-SITE CDF DISPOSAL				
a. Transport by barge and rehandle over berm.	CY	$8	120,000	$ 960,000
TOTAL DIRECT CONSTRUCTION COSTS				**$ 3,772,000**
2. INDIRECT CONSTRUCTION COSTS				
2.1 CONSTRUCTION MANAGEMENT AND SURVEYING	LS	$500,000	1	$ 500,000
2.2 WATER QUALITY MONITORING	week	$12,000	36	$ 432,000
2.3 CONFIRMATIONAL SEDIMENT SAMPLING	sample	$2,500	50	$ 125,000
TOTAL INDIRECT CONSTRUCTION COSTS				**$ 1,057,000**
SUBTOTAL CONSTRUCTION COSTS				**$ 4,829,000**
3. CONSTRUCTION CONTINGENCY	percent	35%	1	$ 1,690,150
TOTAL CONSTRUCTION COSTS				**$ 6,519,150**
4. NON-CONSTRUCTION COSTS				
4.1 SUPPLEMENTAL DESIGN SAMPLING	LS	$200,000	1	$ 200,000
4.2 ENGINEERING DESIGN AND PERMITTING SUPPORT	LS	$500,000	1	$ 500,000
4.3 ENVIRONMENTAL IMPACT REVIEW	LS	$100,000	1	$ 100,000
4.4 REGIONAL BOARD OVERSIGHT COST	YR	$50,000	2	$ 100,000
4.5 HABITAT EVALUATION (EFH) COSTS	LS	$40,000	1	$ 40,000
4.6 HABITAT MITIGATION	Acre	$100,000	TBD	$ -
GRAND TOTAL				**$ 7,459,150**

MODIFICATIONS TO TOTAL	
Alternative 3A - Total with no bulkhead replacement (1.4 a and b)	$ 6,360,150

Table 12
Estimated Cost - Alternative 4

ALTERNATIVE 4 - DREDGING WITH DISPOSAL IN CAD

Cleanup to:
Remedial Activity: **Dredging (Mechanical)**
Disposal: **CAD**

Task	Unit	Unit Cost	Quantity	Total Cost
1. DIRECT CONSTRUCTION COSTS				
1.1 PRE-CONSTRUCTION / SITE PREPARATION				
a. Mobilization/Demobilization	LS	$200,000	1	$ 200,000
b. Prepare Upland Staging, Offloading, Dewatering Area	LS	$100,000	1	$ 100,000
c. Temporary relocation of marinas (incl. reinstallation)	LS	$0	1	$ -
1.2 DEMOLITION	LS	$100,000	1	$ 100,000
1.3 DREDGING (MECHANICAL)				
a. Debris Removal	LS	$150,000	1	$ 150,000
b. Dredging in main channel	CY	$10	82,500	$ 825,000
c. Dredging within marina/seawall areas	CY	$14	27,500	$ 385,000
d. Thin-layer capping of residuals	CY	$20	10,000	$ 200,000
e. Silt Curtain/Oil Boom/BMPs	LS	$100,000	1	$ 100,000
1.4 SEAWALLS & STRUCTURES				
a. Cap for replacement bulkhead (in front of old seawall)	LF	$350	400	$ 140,000
b. Purchase and Install sheetpile bulkhead	LF	$1,500	400	$ 600,000
c. Cap / Rock Buttress along Seawalls. Purchase and place.	TON	$30	5,400	$ 162,000
1.5 SEDIMENT DISPOSAL (CAD)				
a. Excavate CAD	CY	$10	163,000	$ 1,630,000
b. Place dredged material in CAD	CY	$4	120,000	$ 480,000
c. Place confining layer on top of CAD	CY	$10	64,000	$ 640,000
d. Dispose of extra clean sediment.	CY	$4	99,000	$ 396,000
TOTAL DIRECT CONSTRUCTION COSTS				**$ 6,108,000**
2. INDIRECT CONSTRUCTION COSTS				
2.1 CONSTRUCTION MANAGEMENT AND SURVEYING	LS	$750,000	1	$ 750,000
2.2 WATER QUALITY MONITORING	week	$12,000	60	$ 720,000
2.3 CONFIRMATIONAL SEDIMENT SAMPLING	sample	$2,500	70	$ 175,000
2.4 LONG-TERM MONITORING	event	$60,000	5	$ 300,000
TOTAL INDIRECT CONSTRUCTION COSTS				**$ 1,945,000**
SUBTOTAL CONSTRUCTION COSTS				**$ 8,053,000**
3. CONSTRUCTION CONTINGENCY	percent	35%	1	$ 2,818,550
TOTAL CONSTRUCTION COSTS				**$ 10,871,550**
4. NON-CONSTRUCTION COSTS				
4.1 SUPPLEMENTAL DESIGN SAMPLING	LS	$300,000	1	$ 300,000
4.2 ENGINEERING DESIGN AND PERMITTING SUPPORT	LS	$1,000,000	1	$ 1,000,000
4.3 ENVIRONMENTAL IMPACT REVIEW	LS	$200,000	1	$ 200,000
4.4 REGIONAL BOARD OVERSIGHT COST	YR	$50,000	3	$ 150,000
4.5 HABITAT EVALUATION (EFH) COSTS	LS	$60,000	1	$ 60,000
4.6 HABITAT MITIGATION	Acre	$100,000	TBD	$ -
GRAND TOTAL				**$ 12,581,550**

MODIFICATIONS TO TOTAL	
Alternative 4A - Total with no bulkhead replacement (1.4 a and b)	$ 11,482,550

Table 13
Summary of Remedial Alternatives Evaluation

Alternative	Technical Effectiveness		Implementability	Environmental Impacts		Permittability and Institutional Impacts			Cost (millions of dollars)
	Short Term	Long Term		Water Quality	Other Environmental Impacts	Permit Acquisition	Resource Mitigation	Institutional Impacts	
Alternative 1 (No Action)	Poor	Poor	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	Poor	(n/a)
Alternative 2 (Dredge and Upland Disp)	Good	Good	Good	Good	Fair	Good	Good	Good	$17
Alternative 2A (no cost for bulkhead repair)	"	"	"	"	"	"	"	"	$16
Alternative 3 (Dredge and NCDF Disp)	Good	Good	Fair	Good	Good	Good to Fair	Good	Good	$7.5
Alternative 3A (no cost for bulkhead repair)	"	"	"	"	"	"	"	"	$6.4
Alternative 4 (Dredge and CAD Disp)	Good	Good	Fair	Good	Fair to Good	Fair to Poor	Fair	Fair	$12.6
Alternative 4A (no cost for bulkhead repair)	"	"	"	"	"	"	"	"	$11.5

(n/a) = not applicable